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# Status of the Endangered Scotts Valley Spineflower (Polygonaceae) in Coastal Central California

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*Abstract.*—*Chorizanthe robusta* var. *hartwegii* (Scotts Valley spineflower, Polygonaceae) is a narrow endemic plant restricted to a specialized microhabitat (exposed bedrock in California prairie) in Santa Cruz County, California. This taxon and the nominate variety were listed as endangered under the U.S. Endangered Species Act in 1994. Three occurrences of *C. robusta hartwegii* exist on four properties in a recently urbanized area at the northern edge of the city of Scotts Valley. Ten of 80 known colonies are now likely extirpated. In 2014 the primary threats are habitat alteration due to adjacent land uses and developments, and invasive plant species (non-natives) and accumulation of thatch. Using international standards, *C. robusta hartwegii* is critically endangered: area of occupancy, 0.39 ha; extent of occurrence, 1.3 $km^2$; landscape, severely fragmented; and quality of the habitat, continuing to decline. With these attributes, *C. robusta hartwegii* faces an extremely high risk of extinction. As a matter of urgency, we recommend reducing and controlling invasive plant species and thatch using a combination of methods: mowing with biomass removal, cutting by hand tools with biomass removal, pulling by hand with biomass removal, controlled grazing, prescribed mini-burns (testing 1 $m^2$), and spot-treating invasive grasses with a grass-specific herbicide.

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*Chorizanthe robusta* (robust spineflower) is a small annual plant (10 to 30 cm tall) in the buckwheat family (Polygonaceae) and endemic to coastal central California. Two varieties are recognized (Reveal and Morgan 1989, Baldwin et al. 2012): *C. robusta* var. *robusta* (robust spineflower), and *C. robusta* var. *hartwegii* (Scotts Valley spineflower). *C. robusta hartwegii* is diagnosed from the nominate variety by its consistently erect habit (not spreading) and rose-pink involucre lobes (modified leaves subtending the flower) rather than white. The species, inclusive of both varieties, was listed as endangered under the U.S. Endangered Species Act in 1994 (U.S. Fish and Wildlife Service [USFWS] 1994).

The systematics of the species comprising *Chorizanthe* are difficult, confusing (Reveal and Hardham 1989) and unresolved (Kempton 2012). In particular, using molecular techniques and frequencies of haplotypes, Brinegar and Baron (2009) considered *C. r. robusta* to be more closely related to *C. pungens* var. *pungens* (Monterey spineflower) and *C. robusta hartwegii* to be more closely related to *C. pungens* var. *hartwegiana* (Ben Lomond spineflower). Because of their restricted habitats, small geographic ranges and identified threats, *C. p. pungens* and *C. pungens hartwegiana* were likewise listed under the U.S. Endangered Species Act in 1994 as threatened and endangered, respectively (USFWS 1994). Brinegar and Baron (2009) suggested that the four taxa could be

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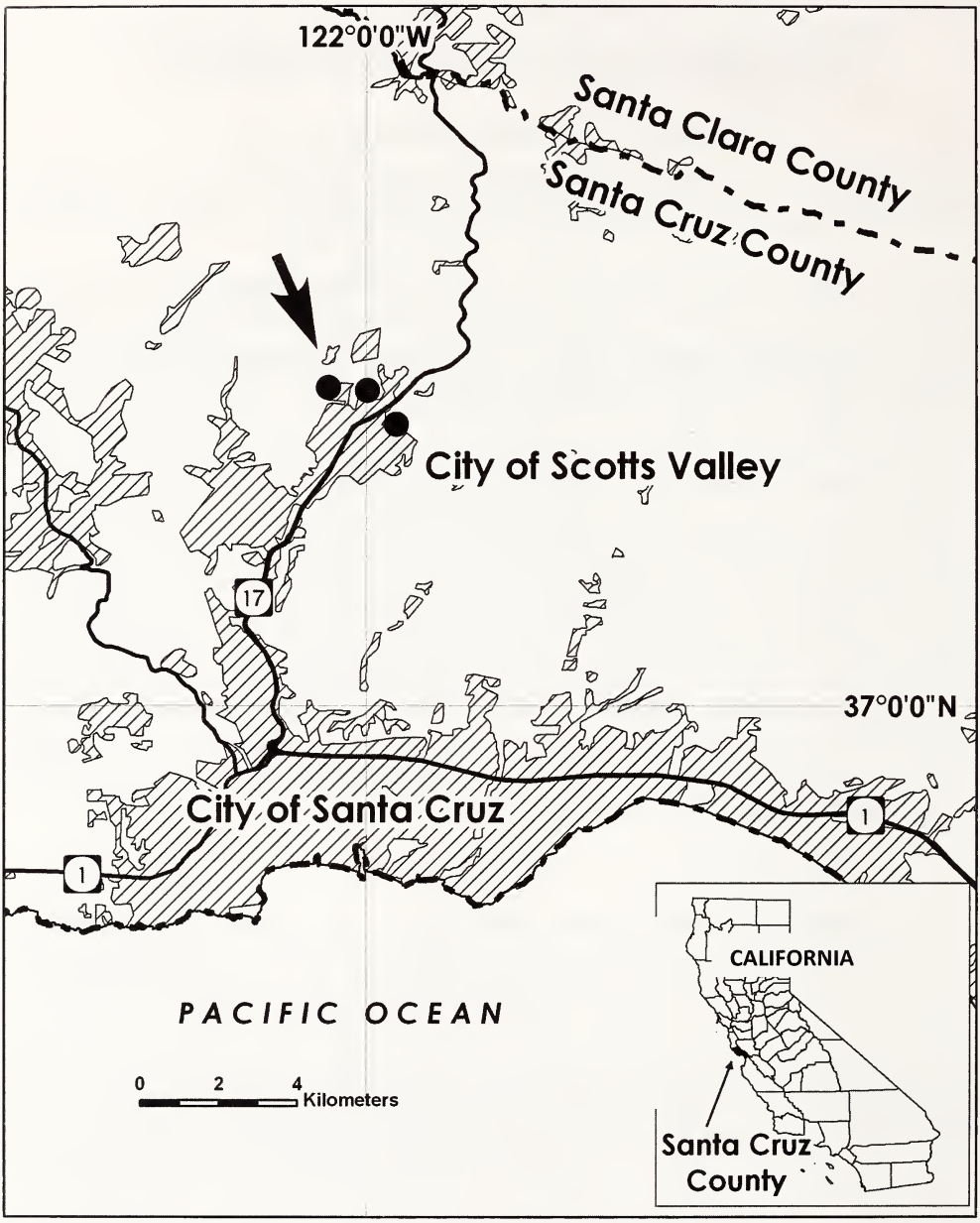


Fig. 1. *Chorizanthe robusta* var. *hartwegii* (Scotts Valley spineflower, Polygonaceae) at the northern edge of the city of Scotts Valley, Santa Cruz County, California. The three occurrences are on four properties. Hatching indicates developed areas.

recognized as four varieties of *C. pungens*. However, Baldwin et al. (2012) continued to recognize *C. r. robusta* and *C. robusta hartwegii* as comprising a separate species.

Reveal and Morgan (1989) reported that *C. robusta hartwegii* exists as three occurrences in the vicinity of the city of Scotts Valley, Santa Cruz County, and 11 km inland from the Pacific Ocean (Figure 1), all within 1.5 km of each other: a western occurrence with several thousand plants, a central occurrence with < 1,000 plants, and an

eastern occurrence with ≈ 1,000 plants. At Federal listing in 1994 the taxon was still known from only three occurrences on four properties. Based largely upon our survey and census data for 1992, USFWS (1994) reported that numbers for the central occurrence and part of the western occurrence ranged from 30,000 to 100,000 plants. Identified threats were a proposed residential development and golf course on three properties with the central and western occurrences, a proposed commercial development on the property with the eastern occurrence, inadequate legal protection and stochastic events.

USFWS (1998) issued a recovery plan for *C. robusta hartwegii*. It recommended preventing extinction by establishing conservation easements, restricting activities to those compatible with the plant, and/or a conservation organization acquiring the four properties. However, USFWS (1998) recognized that recovery might not be possible due to the small geographic range and limited conservation opportunities. New threats included urban development projects (residential developments that would affect all three occurrences, and roads and water facilities near the western occurrence), trampling, invasive plant species (non-natives), pesticides, fertilizers and altered hydrologies. USFWS (2002) reported the total occupied area comprised < 0.4 ha (our data) and considered the following habitat components essential to conservation of *C. robusta hartwegii*: the thin soils in the Bonnydoon series over outcrops of Santa Cruz mudstone and Purisima sandstone, the wildflower fields on the thin soils, the plant community of the California prairie along with the pollinators and seed dispersal mechanisms, the areas around each occurrence for re-colonizing suitable habitat, and the landscape in the watershed above the habitat for maintaining edaphic conditions and hydrology. USFWS (2009) reviewed the status of the taxon and recommended no change in its listing status. Our purpose is to review and enhance the knowledge of *C. robusta hartwegii*, in particular its distribution, ecology, abundance, threats, management and conservation status in 2014.

## Methods

The only primary publications regarding *C. robusta hartwegii* are Reveal and Morgan (1989), USFWS (1994, 1998), and Brinegar and Baron (2009). We have additional and unpublished data because we surveyed, mapped and measured the colonies (spatial groups of separate individuals), censused and made observations during many years from 1990 to 2014. Our surveys and censuses were conducted by systematic search and count when the plants were flowering (April to July). We counted and estimated (after gaining experience by counting) numbers of plants in the following manner: in a colony with < 200 individuals, each plant was counted; in a colony with 200 to 1,000 individuals, plants were estimated to the nearest 20-individuals; and in a colony with > 1000 individuals, plants were estimated to the nearest 100-individuals. We measured cover (relative percent) by native and invasive plant species (in 0.1-m quadrats at 1-m intervals) in May and June 2012 along eight transects (95 m total length) through eight colonies on Polo Ranch Open Space Preserve (37°3.88′N, 121°59.60′W) and along three transects (29 m total length) through three colonies on the western part of Glenwood Open Space Preserve (37°4.32′N, 121°59.00′W). The transects extended 4.6 m beyond each side of the occupied rock outcrops. Using all available information, we summarize and enhance the knowledge of *C. robusta hartwegii*, including its distribution, ecology, abundance, threats, management and conservation status in 2014. We consider a location with the species as a separate occurrence if it is > 0.4 km from the nearest occurrence (California Department

Fig. 2. The three occurrences of *Chorizanthe robusta* var. *hartwegii* (Scotts Valley spineflower, Polygonaceae) at the northern edge of the city of Scotts Valley, Santa Cruz County, California. The polygon with W encompasses the western occurrence on Salvation Army land, Scotts Valley High School land, and the western part of Glenwood Open Space Preserve. The polygon with C encompasses the central occurrence on the eastern part of Glenwood Open Space Preserve. The polygon with E encompasses the eastern occurrence on Polo Ranch. The Google Earth image is dated 14 April 2013.

of Fish and Game 2011). Latin and common names of plants follow Baldwin et al. (2012). The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the USFWS.

## Review of *Chorizanthe robusta* var. *hartwegii*

*C. robusta* var. *hartwegii* is a narrow endemic plant restricted to the specialized microhabitat of exposed bedrock in California prairie (as defined by Holstein 2011, equates to California annual grassland of Sawyer et al. 2009) in coastal central California. In 2014 the taxon is still known from only three occurrences on four properties in a recently urbanized area at the northern edge of the city of Scotts Valley (Figure 2). The western occurrence is on three contiguous properties: Salvation Army land (37°4.30′N, 122°0.58′W; private), Scotts Valley High School land (37°4.16′N, 122°0.53′W; public), and the western part of Glenwood Open Space Preserve (public). The central occurrence is on the eastern part of Glenwood Open Space Preserve. These two occurrences are west of State Highway 17, which is an expressway through the city. The eastern occurrence is

on Polo Ranch Open Space Preserve (private) and east of State Highway 17. Scotts Valley High School land, Glenwood Open Space Preserve and Polo Ranch Open Space Preserve are within city limits, whereas Salvation Army land is not. The geographic range comprises 1.3 $km^2$, with 1.2 km separating the western and eastern occurrences. We have identified 80 colonies since 1990: western occurrence, 38 colonies; central occurrence, 8 colonies; and eastern occurrence, 34 colonies.

The landscape in which *C. robusta hartwegii* occurs is inhabited also by three other endangered species: *Polygonum hickmanii* (Scotts Valley polygonum, USFWS 2003), *Plagiobothrys diffusus* (San Francisco popcorn flower, California Department of Fish and Wildlife 2013), and *Cicindela ohlone* (Ohlone tiger beetle, USFWS 2001). We and others have conducted numerous searches for all four taxa. Although *C. robusta hartwegii* is a small plant, its microhabitat is easy to identify. Some additional occurrences may exist but have not been found. However, most other areas likely to have supported this taxon are now developed, and it seems unlikely that any additional occurrences exist. Development of the city of Scotts Valley and construction of State Highway 17 probably removed any other occupied habitat. *P. hickmanii* is endemic to and occurs on three of the properties (Kofron et al. 2013). *P. diffusus* occurs on two of the properties (pers. obs.) and *C. ohlone* on one (Cornelisse et al. 2013, Knisley and Arnold 2013), although each has a broader geographic range.

*C. robusta hartwegii* germinate during the winter (wet season), flower during April to July, dry and turn a rusty hue during the summer (dry season), and eventually break apart during the fall. Depending on vigor of individual plants, dozens to possibly hundreds of seeds are produced per plant, with seed maturation by August. The plants occur in colonies in full sun in California prairie at 229 to 244 m elevation (Reveal and Morgan 1989) in two types of situations: in patches of thin soil overlying and derived from exposed bedrock (Santa Cruz mudstone and Purisima sandstone) on gently sloping to nearly level ground, and on steep outcrops of the exposed bedrock. In the vicinity of the city of Scotts Valley, California prairie is generally on the middle to lower slopes (213 to 244 m, Hinds and Morgan 1995), with *Sequoia sempervirens* (redwood) and mixed forest on higher slopes (USFWS 2003). Based on data for the Ben Lomond weather station (6.3 km west northwest of Salvation Army land), mean annual rainfall at the three occurrences is $\approx$ 1,186 mm, along with rain primarily from November to April (http://www.worldclimate.com 2013). Other important factors appear to be the particular characteristics of the thin soil: its fine texture, relative sterility and distinctive hydrology (Kofron et al. 2013). In addition, many of the patches of thin soil bear a cryptogamic crust (cyanobacteria, lichens, mosses and fungi on the soil surface). Cryptogamic crusts are important elements of semiarid and arid ecosystems (Beymer and Klopatek 1992) because they stabilize soil against erosion, fix atmospheric nitrogen, form organic matter (Eldridge and Greene 1994), retain soil moisture, discourage weed growth (Belnap et al. 2001) and provide favorable sites for growth of native plants (e.g., Lesica and Shelly 1992). We have observed *C. robusta hartwegii* growing both in and beyond the cryptogamic crusts.

In 2014 the local California prairie is dominated by invasive annual grasses (Poaceae) that include *Aira caryophyllea* (silver hair grass), *Avena barbata* (wild oat), *Briza maxima* (rattlesnake grass), *Bromus hordeaceus* (soft chess) and *Festuca myuros* (rattail sixweeks grass), which produce thatch. However, some patches of thin soil associated with the exposed bedrock are still dominated by native annual forbs that comprise a distinct community of native wildflowers, which USFWS (1994, following Holland 1986) referred

to as wildflower fields. The native species associated with *C. robusta hartwegii* in this plant community include the equally narrow endemic *P. hickmanii*, *Acmispon brachycarpus* (deervetch), *Castilleja densiflora* (owl's-clover), *Deinandra corymbosa* (coastal tarplant), *Lasthenia gracilis* (common goldfields), *Lepidium nitidum* (peppercress), *Minuartia californica* (California sandwort) and *Trichostema lanceolatum* (vinegar plant). The greatest diversity of native plants within the wildflower fields is generally on the thinner soil. The soil underlying most other parts of the local California prairie is thicker and with more humus and nitrogen.

The proposed residential development and golf course that threatened the central and western occurrences in 1994 were never built. However, other developments have directly or indirectly impacted them: the Scotts Valley Water District recycled water tank, the Scotts Valley High School, and the residential developments immediately east and west of the central occurrence. The commercial development that previously threatened the eastern occurrence was completed in 1994 (Borland International Headquarters) and without direct impacts.

*Salvation Army Land (Part of Western Occurrence)*

Salvation Army land comprises 83 ha of California prairie and forest immediately west of Scotts Valley High School land and Glenwood Open Space Preserve. We have recorded 13 colonies on the property (all on the southern half), one of which is shared with Glenwood Open Space Preserve (west). In the mid 1990's, the California Department of Fish and Game recommended that one large preserve be established for the sensitive plant species on Salvation Army land and the adjacent part of Scotts Valley High School land. However, negotiations for a conservation easement on Salvation Army land were not successful (California Department of Fish and Game 2004). Scotts Valley Water District built a recycled water tank on this property in 1999 (USFWS 2003), along with a paved road 20 m upslope of five colonies. We conducted two surveys and censuses on this property (Table 1): 1992 (32,066 plants), and 2009 (6,336 plants). The natural ecosystem on Salvation Army land is now impacted by development and also degraded by invasive plant species and accumulation of thatch. Intensive management is urgently needed.

*Scotts Valley High School Land (Part of Western Occurrence)*

Scotts Valley High School land (8 ha) is bounded by Salvation Army land to the west and Glenwood Drive and residential development (mostly Glenwood Estates, 45 houses on 14 ha) to the east. Construction of the high school commenced in 1998. Four colonies of *C. robusta hartwegii* (790 plants in 1998) were in the construction footprint of the high school, which we salvaged in 1999 and transplanted (soil with seed bank) to a revegetation area on the western part of the property that is subject to a management plan in perpetuity. However, this area was subsequently compacted by heavy equipment, and no *C. robusta hartwegii* emerged. The Scotts Valley High School Ecological Preserve (3.2 ha of California prairie) was established on the southern part of the property to conserve some of the sensitive plant species (*C. robusta hartwegii*, *P. hickmanii, P. diffusus*), and it is subject to a management plan in perpetuity. We have identified 13 colonies in the ecological preserve. Development surrounds it on three sides: high school facilities, paved road and athletic fields immediately north; and houses immediately south and east. Although now fenced, students previously crossed the ecological preserve, bicycle jumps were erected in it, golfers used it for practice, and concrete and other waste

Table 1. Approximate numbers of *Chorizanthe robusta* var. *hartwegii* (Scotts Valley spineflower, Polygonaceae) at the northern edge of the city of Scotts Valley, Santa Cruz County, California, from 1992 to 2012. We surveyed and censused by systematic search and count when the plants were flowering (April to July).

| | | Year | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Occurrence | Property | 1992 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2012 |
| Western | Salvation Army land | 32,066 | | | | | | | | | | | | | 6,336 | | |
| | Scotts Valley High School land | | 16,980 | 16,500 | 5,000 | 15,250 | 11,500 | 12,000 | 13,000 | | | | | | 10,525 | | 17,236 |
| Central | Glenwood Open Space Preserve | 41,141 | | | | | | | | 25,237 | 28,118 | 10,642 | 11,201 | 9,451 | 16,769 | 29,899 | |
| Eastern | Polo Ranch Open Space Preserve | | 7,950 | 6,322 | | | | | 13,595 | 9,931 | 7,799 | | | | | 19,246 | 14,150 |

were dumped in it (USFWS in Kofron et al. 2013). We saw no evidence of unauthorized activities from 2009 to 2013. Mowing without removing the cut biomass occurred annually from 1998 to 2011, and at our recommendation the cut biomass was removed in 2012. Also at our recommendation, controlled horse grazing to reduce the invasive grasses and benefit the sensitive plant species commenced in 2013.

We conducted nine surveys and censuses on Scotts Valley High School land from 1997 (16,980 plants in 17 colonies) to 2012 (17,236 plants in 13 colonies). In 1999 we recorded 5,000 *C. robusta hartwegii* on the property (all in the ecological preserve), which is the lowest number for any census. The low number likely resulted because of disturbances during construction of the high school, disturbances during construction of the road to access the water tank on Salvation Army land, and disturbances by construction and use of bicycle jumps in the largest colony. The natural ecosystem on the ecological preserve is now impacted by development and also degraded by invasive plant species and accumulation of thatch. The ecological preserve is not large enough to sustain a natural ecosystem, and the adjacent land uses on three sides are not compatible. The controlled horse grazing is expected to help improve the situation.

*Glenwood Open Space Preserve (Central Occurrence and Part of Western Occurrence)*

Glenwood Open Space Preserve comprises 67 ha of California prairie and forest that are north, northwest and east of Scotts Valley High School land (separated by Glenwood Drive and Glenwood Estates). In 1992 we documented 17 colonies (41,141 plants) on the property, one of which is shared with Salvation Army land. In 2003 the City of Scotts Valley and Ponderosa Homes agreed to development of Glenwood Estates, along with establishing the open space preserve with ownership by the City and an endowment for management ($1,070,000). The houses were built from 2003 to 2005. Since 2003 the sensitive species and their habitats have been managed in accordance with a natural resource management plan. Controlled horse grazing commenced on the eastern part of the open space preserve (where eight colonies of *C. robusta hartwegii* have been recorded) in 2004, which appears to reduce invasive annual grasses and thatch. Since 2009 the City of Scotts Valley and the Land Trust of Santa Cruz County jointly manage the open space preserve. However, Scotts Valley Water District now has approval to install a facility on the property that could adversely affect *C. robusta hartwegii*. Although it is currently closed to the public, a plan to allow low-intensity recreation (e.g., hiking) is being prepared. In 2010 we observed only 10 colonies (29,899 plants): seven colonies were not seen, including five previously impacted by the dumping of construction debris and yard waste in the southeastern corner. In 2012 the invasive plant species on the western part of the open space preserve were primarily of families other than Poaceae: *Erodium botrys* (storksbill, Geraniaceae), *Hypochaeris glabra* (smooth cat's-ear, Asteraceae), *Linum* sp. (flax, Linaceae), *Logfia gallica* (daggerleaf cottonrose, Asteraceae), *Rumex acetosella* (sheep sorrel, Polygonaceae), *Silene gallica* (small-flower catchfly, Caryophyllaceae) and *Trifolium angustifolium* (narrow-leaved clover, Fabaceae). Cover by invasive plant species ($n$ = 11) in the occupied habitat of *C. robusta hartwegii* was 79%, and cover by native plant species ($n$ = 3) was 21%.

*Polo Ranch (Eastern Occurrence)*

Polo Ranch comprises 46 ha of California prairie and forest immediately north of residential development, and its natural ecosystem is now degraded by invasive plant species and accumulation of thatch. We conducted seven surveys and censuses of *C.*

*robusta hartwegii* on Polo Ranch from 1997 (7,950 plants) to 2012 (14,150 plants), and we have identified 34 colonies. In 2013 the occupied area (23 colonies) comprises 683 $m^2$. From 1998 to 2005 we observed disturbances to several colonies by grading for a firebreak and by off-highway vehicles, the latter which the landowner deterred by fencing in 2006. In 2009 the City of Scotts Valley approved a plan to construct 40 houses on 5 ha, along with establishing an open space preserve on 41 ha of which 12 ha of sensitive habitat would be fenced and under a conservation easement. The area under conservation easement will be managed by a conservation organization to benefit the listed plant species (*C. robusta hartwegii*, *P. hickmanii*, *P. diffusus*), including controlled grazing to reduce invasive plants along with other adaptive management practices. Although development will not destroy any occupied area, its footprint will extend to 30 m from the nearest colony of *C. robusta hartwegii* (USFWS 2012). Vegetation clearing for construction commenced shortly after our survey and census in June 2012. Cover by invasive plant species ($n$ = 22) and native plant species ($n$ = 11) in the occupied habitat was 94% and 6%, respectively, in 2012.

## Conservation Status

The cessation of grazing (Salvation Army and Scotts Valley High School lands, 1970's; Glenwood Open Space Preserve, 1980; Polo Ranch, early 1990's) and fire suppression have likely contributed to the increasing presence of invasive plant species (and also rank natives such as *Baccharis pilularis* [coyote brush]) and accumulation of thatch. We suspect that grazing and fire previously benefited *C. robusta hartwegii* by reducing the invasive plant species and accumulated thatch in its habitat. The mechanisms by which the invasive species impact *C. robusta hartwegii* are not known, however, they may inhibit germination and seedling survival (e.g., Thomson 2005) or compete for limited resources. Also, it seems likely that accumulated thatch from the tall invasive annual grasses will eventually cover much of its microhabitat.

Species with small geographic ranges are more vulnerable to extinction by stochastic events (Ricklefs 2008), which include severe storms, freezes, harsh winters, fires and droughts (Mangel and Tier 1994). *C. robusta hartwegii* is a taxon with a small occupied area (0.39 ha, measured 1990 to 2002) and a small geographic range (1.3 $km^2$). With these attributes, *C. robusta hartwegii* is highly vulnerable to stochastic events. In addition, USFWS (2009) identified climate change as a new threat. In consideration of the life history traits used by Anacker et al. (2013) for assessing climate change vulnerability in California, *C. robusta hartwegii* is highly vulnerable because of its low dispersal ability and habitat specialization.

Since listing in 1994, the landscape with the three occurrences of *C. robusta hartwegii* has become increasingly developed and fragmented, with development impacts resulting in the likely extirpation of 10 colonies (western occurrence, 4 colonies; central occurrence, 5 colonies; eastern occurrence, 1 colony). In 2014 the primary threats are habitat alteration due to adjacent land uses and developments, and invasive plant species and accumulation of thatch. Although *C. robusta hartwegii* is listed as endangered under the U.S. Endangered Species Act (USFWS 1994), this law provides little protection against the threats in 2014. Using our information and international standards (IUCN 2011, 2012), *C. robusta hartwegii* in 2014 meets the IUCN criteria for critically endangered: area of occupancy, 0.39 ha; extent of occurrence, 1.3 $km^2$; landscape, severely fragmented; and quality of the habitat, continuing to decline. With these attributes, *C. robusta hartwegii* faces an extremely high risk of extinction. Therefore, as a matter of urgency, we

recommend reducing and controlling invasive plant species and thatch using a combination of methods: mowing with biomass removal, cutting by hand tools with biomass removal, pulling by hand with biomass removal, controlled grazing, prescribed mini-burns (testing 1 $m^2$), and spot-treating invasive grasses with a grass-specific herbicide.

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# From Progesterone in Biopsies to Estimates of Pregnancy Rates: Large Scale Reproductive Patterns of Two Sympatric Species of Common Dolphin, *Delphinus* spp. off California, USA and Baja, Mexico

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*Abstract.*—Blubber progesterone levels were measured in biopsy samples and used to predict the pregnancy status of 507 female common dolphins (204 long-beaked common dolphins, *Delphinus capensis*, and 303 short-beaked common dolphins, *D. delphis*). Samples were collected in the coastal waters of the eastern North Pacific between central California, USA and the southern end of Baja California, Mexico. The percentage of females pregnant was similar between the two species: 22.1% ($n$ = 45) of *D. capensis* and 28.1% ($n$ = 85) of *D. delphis*. For both species we found strong geographic patterns in pregnancy, suggesting that some areas were more conducive for pregnant females. A sizable drop in percent pregnant from early (38.8%, $n$ = 133) to late (25.3%, $n$ = 91) autumn was found in *D. delphis* but not in *D. capensis*. The potential for sample selectivity was examined via biopsies collected either from a large research ship or from a small, rigid-hull inflatable boat (RHIB) launched from the larger ship. An analysis of "Tandem Biopsy Sampling", replicate biopsy effort on the same schools from each vessel/platform, yielded little evidence that disproportionately more pregnant female common dolphins were biopsied from one platform versus the other. This result plus an analysis of pregnancy status relative to the duration of biopsy operations failed to uncover strong evidence of unaccounted sampling bias with respect to pregnancy state. In total, these results demonstrate the utility of blubber progesterone concentrations to assess pregnancy status in free-ranging cetaceans and they highlight potential factors associated with population-level variation in dolphin pregnancy rates.

## Introduction

In this study, we use hormone measurements collected from biopsy samples to evaluate pregnancy patterns in the two species of common dolphins in the eastern North Pacific. The overarching goals of this study are two-fold. The first is to investigate how pregnancy of these common dolphins varies with respect to species, season, geographic location, and schooling behavior. The second goal is to evaluate the potential sample selectivity of biopsies relative to pregnancy state. Because this is one of the first times that biopsies have been used to assess pregnancy parameters at a population level, it is important to assess whether data from these samples are suitable for such an analysis.

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### *Common Dolphins and Reproduction*

The short-beaked common dolphin, *Delphinus delphis,* and the long-beaked common dolphin, *D. capensis*[1] are remarkably similar in many aspects of their appearance, behavior, and biology (Heyning and Perrin 1994). While *D. capensis* is typically found within 185km (100nmi) of the coast from Central California south to the Gulf of California (Carretta et al. 2011, Gerrodette and Eguchi 2011), *D. delphis* has a much larger range and inhabits waters well west of the US exclusive economic zone (within 200nmi of the coast), north to Oregon and Washington and south to the southern tip of Baja California, Mexico. The distributions of the two species overlap within our study area, and on rare occasions, schools of the two species have been found immediately adjacent to one another (Heyning and Perrin 1994).

Due to its great abundance (arguably the most abundant cetacean in the world) and frequent entanglement in various fisheries worldwide, many more reproductive data have been collected from *D. delphis* than from *D. capensis*. *D. delphis*-specific reproductive parameters have been derived mainly from animals killed as bycatch in commercial fisheries in several regions of the Pacific and Atlantic oceans (Ferrero and Walker 1994, Danil and Chivers 2007, Westgate and Read 2007, Murphy et al. 2009). The percent of sexually mature females that are found pregnant within these data sets varies between the different areas, with perhaps greater rates in the tropical regions of their distribution. The percent pregnant ranges from a low of 25.0% ($n_{\text{mature females}}=8$) (Ferrero and Walker 1994) in the central North Pacific, 26% ($n_{\text{mature females}}=248$) (Murphy et al. 2009) and 33% ($n_{\text{mature females}}=39$) (Westgate and Read 2007) in the eastern and western North Atlantic, respectively, to a high of 44.4% ($n_{\text{mature females}}=333$) in the eastern tropical Pacific (Danil and Chivers 2007). Spatiotemporal variation in the occurrence of pregnancies has not been highlighted in published studies, although Murphy et al. (2009) reported that within the eastern North Atlantic region, the UK/French oceanic area had substantially higher percentage of sexually mature females pregnant: 28% ($n_{\text{mature females}}=191$) than in either the Irish Sea: 20% ($n_{\text{mature females}}=25$) or Iberian Sea: 19% ($n_{\text{mature females}}=32$).

There is much less reproductive information regarding the other *Delphinus* species, *D. capensis*. Due to its lower worldwide abundance (Perrin 2009, Carretta et al. 2011) and only recent recognition as a separate species in the mid-1990s (Heyning and Perrin 1994, Rosel *et al.* 1994), no population-level pregnancy estimates have been made for this species. However, during the field effort that generated the biopsies used in the analysis for this paper, aerial images were taken and a subsequent paper estimating calving rate has been produced for *D. capensis* and *D. delphis* (Chivers et al. 2012). The percent calves out of all animals photographed (including males and females) were 4.5% and 6.7% for *D. capensis* and *D. delphis* respectively, translating into approximately 18.8% and 26.8% percent pregnant respectively, given several demographic assumptions.[2]

### *Projectile Biopsies and Sample Selectivity*

Projectile biopsies are increasingly used to address life-history questions (Mansour et al. 2002, Kellar et al. 2006, Kellar et al. 2009, Perez et al. 2011, Trego et al. 2013) including those regarding pregnancy. When interpreting results of biopsy-based

[1] *D. capensis* and *D. delphis* references in this paper are intended to be synonymous with the subspecies, *D. c. capensis* and *D. d. delphis*, respectively (Perrin 2011a, 2011b).

[2] This assumes a 1) 50:50 sex ratio, 2) 50:50 mature to immature ratio and 3) no fetal/neonatal mortality.

life-history studies in the context of population parameters, it is important to know how representative the samples are of the populations from which they are collected. Non-random sampling can lead to spurious results when conclusions from sample sets are generalized to the overall populations. Evaluating potential factors that may influence whether biopsy-obtained data represent a random sample of the population will facilitate correcting for sampling biases when estimating demographic parameters and in designing future experiments to estimate parameters.

In this study, we examine, for the first time, the likelihood of being pregnant with respect to various factors, such as vessel type, biopsy collection order, geographic location, school size, and sampling date. Some of these factors are associated with the biopsy process, which helps us assess the potential for sample selectivity, while others are aimed at examining spatiotemporal variation in pregnancy rates among species.

## Materials and Methods

### *Biopsy Collection*

We collected 507 biopsy samples from female common dolphins off Central and Southern California, USA and Baja California, Mexico in 2009 (Chivers et al. 2010) during a three-month research cruise (Leg 1: Sept. 7$^{th}$–Oct. 2$^{nd}$ [early autumn], Leg 2: Oct. 8$^{th}$–Nov. 6$^{th}$ [mid autumn], and Leg 3: Nov. 12t$^{h}$–Dec. 9$^{th}$ [late autumn]), using 150 lb Barnett Wildcat crossbows (Barnett Outdoors, LLC, Tarpon Springs, FL, USA) Excalibur Apex-Lite crossbows (Excalibur Crossbow, Kitchener, ON, Canada) with carbon fiber darts (Ceta-Dart, Hovedstaden, Denmark) fitted with multi-barbed stainless-steel biopsy tips. Samples included an approximately 7-mm diameter skin plug attached to an approximately 20-mm long plug of blubber. Mean mass of blubber attached to these biopsies was 0.091g (SE = 0.003g). All samples were frozen in a −80°C freezer after collection.

Most biopsies (n = 376) were collected from dolphins riding the bow of the NOAA Ship *McArthur II*, a modified 224ft T-AGOS class surveillance vessel. Targeted dolphins rode the bow between 0 and 6 meters away from the ship, most directly under the positions where biopsy collectors were stationed approximately 10 meters above the waterline. The remaining samples (n = 131) were collected from a 6-meter Zodiac rigid-hull inflatable boat (RHIB) launched from the NOAA Ship *McArthur II*. Irrespective of platform, biopsy collectors were not permitted to target suspected mother/calf pairs (identified by size characteristics and observing one individual swimming in calf or echelon position with respect to another).

There were two categories of biopsy sampling. The first was the standard method used by Southwest Fisheries Science Center research cruises over the last 20 years, in which 1–15 biopsies were gathered per school, mostly from the ship but a few also from the RHIB. These samples represented more than half of all biopsies collected for this study. The second category of sampling was dubbed "Tandem Biopsy Sampling". During this effort, in order to minimize the effects of demographic differences inherent to schools, we collected a subset of biopsies (n = 207), from both platforms (RHIB = 111, Ship = 96) from single schools. Samples were obtained systematically, with the goal of obtaining 15 samples per platform per school. For such schools (n = 18), the sampling was done sequentially, such that approximately 15 biopsies (from both males and females; only the females were used in this study) each were obtained first from one platform and then the other, with a break in sampling on the order of 15 minutes to one hour. We alternated between starting the sampling effort on a given school from the

ship and from the smaller RHIB. Due to logistical constraints, perfect alternation was not possible, but in the aggregate, we obtained similar-sized sample sets for each platform (n = 10 and 8 schools sampled from the RHIB first and ship first, respectively).

The intent in comparing the number of pregnant female dolphins sampled from the two platforms was to assess the potential sample selectivity biases of biopsy collection. Because of the limited mobility of larger research ships, the composition of samples is highly dependent on the behavior of individual animals approaching the ship and making themselves available for biopsy (i.e., bowriding). However, when sampling from the smaller and more maneuverable RHIB, biopsy collectors are less dependent on bowriding animals. Smaller boats can better maneuver through schools and biopsy collectors can target a greater range of animals, not limited to only bowriding individuals (in fact the majority of animals that bowride small boats are too close for biopsy with the crossbows we have used). From this perspective, if demographically linked bowriding behavior was contributing to a bias in percent pregnancy, we would expect that biopsies collected from a small boat to be more representative of the sampled population.

*Molecular Sex Determination*

DNA was extracted using the Corbett Robotics DNA Extractor (Qiagen, Valencia, CA, USA) and in some instances manually with the NaCl-'salting out' method. Sexes were determined using the Stratagene MX3000P qPCR (Agilent Technologies, Santa Clara, CA, USA) following the protocol established by Morin et al. (2005). Positive control tissue from one known male and one female, determined by genital inspection of reference specimens from a stranding or fishery-bycatch, was included on each assay to assess reaction quality.

*Blubber Progesterone Isolation*

The blubber hormone extractions followed the methods delineated in Kellar et al. (2006) with several modifications to simplify the procedure and increase consistency. Approximately 0.05g−0.15g of blubber was homogenized in 1000uL of 100% ethanol using a Fast Prep 24 homogenizer (MP Biomedicals, Santa Ana, CA, USA) and lysing matrix "A" tubes (MP Biomedicals, Santa Ana, CA, USA). The samples were processed seven to nine times at a speed of 5 m/s for 45-second intervals depending on sample consistency. The contents of each lysing matrix tube were poured into a glass tube and the lysing matrix tube was rinsed with 500uL of ethanol. The homogenate:ethanol solution was then separated from the grinding media and placed into a new glass tube. The lysing matrix tubes and grinding media were rinsed again with another 500uL of ethanol and combined with the homogenate. The homogenate/rinse solution combination was combined with 2 ml of 4:1 ethanol acetone. The resulting solution was vortexed and then centrifuged at 4000 rpm for 15 min. The supernatant was transferred and evaporated. Two milliliters of diethyl ether were added, vortexed and centrifuged again. The supernatant was collected and evaporated, and the residue was resuspended in 1000 μL of acetonitrile, vortexed, and 1000 μL of hexane added to the mixture. After the solution was vortexed and centrifuged again, the acetonitrile layer was aspirated into a new tube and the process was repeated with another 1000 μL of hexane. The final portion of acetonitrile was collected and evaporated. The remaining residue was centrifuged at 4000 rpm for five minutes and stored at −20°C.

*Progesterone Enzyme Immunoassay*

To prepare the samples for the enzyme immunoassay (EIA), they were suspended in varying amounts (250 or 1,000 μL) of 1M phosphate buffered saline. In order to make measurements in accurate detection range on the EIA, samples were resuspended in 250 μL of PBS then vortexed in the multitube vortex for 15 min. We used an EIA kit 900-011 (Enzo Life Sciences, Plymouth Meeting, PA, USA) that has 100% reactivity with progesterone and 5α-Pregnane-3,20-dione in each sample. The assay detection limits were between 15 and 500 pg/mL. Therefore, samples that exceeded this range had to be diluted further to be accurately measured. These samples were diluted at 1:100, 1:20, 1:5, 1:3, and 1:2 depending on their original EIA measurements such that the final measurements would fall within the range of the control samples. The intra-assay coefficient of variation (CV) was between 4.9% and 7.6% and an inter-assay CV between 2.7% and 6.8%. Each sample was individually vortexed prior to quantifying progesterone concentration.

We determined the extraction efficiency using spiked samples as described in Kellar et al. (2006). The extraction control samples were spiked with 0 ng, 10 ng, and 30 ng of cold (i.e., non-radioactive) progesterone. The percentage of progesterone that was recovered after each extraction set (i.e., group of samples processed at the same time) was calculated and each assay value was adjusted to the standard prior to analysis. The mean extraction efficiency was 89.3% (SE = 4.8%). Once corrected for extraction efficiency, it was assumed that progesterone concentrations greater than 50 ng per gram of tissue were from pregnant females (Kellar et al. 2006).

"Percent pregnant" as reported here should be understood as the percent that were pregnant out of all females sampled (both mature and immature). Because maturity state was not identifiable from the field observations or biopsy sample, this is a different metric than usually reported from carcass data, which is the percent pregnant out of only the sexually mature females sampled.

*Statistical Analysis*

We assessed a suite of factors associated with the biopsy sampling process as potential correlates with percent pregnant. They included species (*D. delphis*, *D. capensis*), latitude, longitude, platform (i.e., vessel: research ship or RHIB), school size and duration of biopsy activity/perturbation[3]. Platform and biopsy duration[4] are the two factors directly related to the biopsy process, whereas latitude, longitude, and school size were not. Julian date (more specifically the month of collection) was a factor also examined, but given its strong relationship with location during the survey, we conducted its analysis separately with a different methodology; see below.

Each of these factors' predictive ability was assessed as part of a Bayesian model-averaging procedure using a method in which the model estimation process selects the factors to include and which to exclude for each iteration of a Markov chain Monte Carlo run (Carlin and Chib 1995). In this analysis, sets of nested logistic generalized linear

[3] All independent variables were normalized to have a mean of zero and a variance of one to minimize the effects of differences in absolute values on the model results.

[4] Duration of biopsy activity/perturbation was measured by rank order of a biopsy in a series of samples for a particular sampling bouts (e.g., the fifth biopsy taken from a particular school would receive a rank of 5). Rank order may not be exactly comparable between biopsying bouts; the amount of time of each bout varies, so that for example, the 5$^{th}$ sample in one bout may have been taken much earlier relative to when the animals had begun bowriding than the 5$^{th}$ sample in another bout.

Table 1. Bayes factor ($B_{10}$) interpretation. These are descriptive statements about standards of evidence in scientific investigation as proposed by Kass and Raftery (1995). Example: for a simple linear regression if zero lies just beyond either end of the 90% probability interval of the posterior distribution of the slope coefficient, the corresponding Bayes Factor would be nearly 20, "strong" evidence.

| Bayes Factor ($B_{10}$) | Evidence against $H_0$ |
|---|---|
| 1 to 3 | Not worth a mention |
| 3 to 20 | Positive |
| 20 to 150 | Strong |
| > 150 | Very strong |

models were constructed in WinBUGS (Lunn et al. 2000) with each factor multiplied by a Bernoulli selection parameter in the form[5]:

$$\begin{aligned}\text{logit}\left(p_{\text{pregnant}(i)}\right) = a &+ \gamma_{lat} * b_{lat}\left(x_{i,lat}\right) + \gamma_{long} * b_{long}\left(x_{i,long}\right) \\ &+ \gamma_{platform} * b_{platform}\left(x_{i,platform}\right) + \gamma_{s_size} * b_{s_size}\left(x_{i,s_size}\right) \\ &+ \gamma_{b_order} * b_{b_order}\left(x_{i,b_order}\right)\end{aligned} \quad (1)$$

where $p_{\text{pregnant}(i)}$ is the probability that individual $i$ is female, $b$ is the marginal slope coefficient for each factor, and $\gamma_j$ was the selection parameter for each factor ($j$) with a probability equal to the mean of $\gamma_j$. 300,000 iterations were used for the model runs, starting from three sets of initial points, with a burn-in period of 1,000 iterations. Every third iteration thereafter was incorporated into the parameter estimates, yielding a posterior distribution from 100,000 iterations. Vague priors were set for all marginal slope and intercept coefficients from normal distributions, each with mean = 0 and variance = 1000 (note: these prior distributions where variance > 1000 had poor convergence). The prior on each selection parameter $\gamma_j$ was set to be $p = 0.5$. The weight (an indication of importance) that each factor had on the estimate of the sampled animal's pregnancy state was equal to $\gamma$ and directly proportional to the number of iterations in which that factor was selected in the MCMC chain. Marginal posterior probabilities of the selection parameters with median values greater than $p = 0.5$ were those in which the weight of evidence supported their inclusion in the model.

For the "Tandem Biopsy Sampling" experiment, the difference in the proportion pregnant between platforms for each school was estimated using a Bayesian model, similar to a frequentist paired t-test (Manly 1991). By estimating the difference for each school, the analyses would not be influenced by inter-school demographic variability (e.g., nursery schools - schools disproportionately composed of mothers with calves). Difference in proportion pregnant estimations (not paired) were also used to analyze the effects of Julian date or season and to compare the proportion pregnant in three different geographic areas: north of Pt. Conception (Central California), Pt. Conception to US/Mexico border (Southern California), south of border (Baja California, Mexico).

The Bayesian results are reported as both Bayesian posterior probabilities and Bayes factors ($B_{10}$). We have included a table (Table 1) with description statements for interpretation of Bayes factors adapted from Kass and Raferty (1995).

Finally, spatial analyses were conducted to examine geographical variation in pregnancy. Interpolated surfaces of proportion pregnant were mapped using inverse

[5]A logit link function was used, as the pregnancy data were coded as 0/1, corresponding to the probability that a sample was pregnant: 0 = not pregnant, 1 = pregnant.

distance weighting with ArcMap 9.1 (ESRI, Redlands, CA, USA)[6]. Statistical significance of spatial variation in proportion pregnant as determined from the biopsies (each datum equals 0 or 1, based on whether the biopsy was from a non-pregnant or pregnant female, respectively) was analyzed using permutation tests of Ripley's K (Ripley 1977, Besag and Clifford 1989), a metric that evaluates the distribution of pregnancy against a random distribution. Ripley's K is particularly useful at determining if "hot spots" (i.e., disproportional clumping) exist within an analyzed data set[7].

## Results

Of the 507 biopsy samples collected, blubber progesterone concentrations of nominally pregnant females (i.e., those that were estimated to be pregnant based on blubber progesterone concentrations greater than the threshold criterion of 50 ng/g) were approximately two orders of magnitude greater than those of nominally non-pregnant ones (Figure 1 and Table 2). Using the same threshold criterion, 22.1% (45 of 204) of the biopsied female *D. capensis* were determined to be pregnant, while 28.1% (85 of 303) of biopsied female *D. delphis* were determined to be pregnant (Table 3). Varying the threshold criterion ±20 ng had only small effects on the percent pregnant of either species (Table 4)[8].

This yields a 92.9% posterior probability ($B_{10}$=13.0) that the *D. delphis* in the study area had a higher proportion pregnant than the *D. capensis* in that same area. We found the percent pregnant was lower in biopsies collected from the RHIB than those collected from the ship for both species (>10 percentage point differences in both species; Table 3). Note that evidence of this difference disappears for *D. delphis* when the analysis is restrained to tandem biopsy sampling or when additional factors are incorporated along with platform into our analyses (see below).

### *Evaluating the Effects of Biopsy-related and Biopsy-unrelated Factors on Pregnancy*

Potential factors differentiating the two species (Figure 2 and Figure 3) were highlighted in the Bayesian model averaging results. For *D. capensis,* only the posterior for the sampling platform coefficient (median = 0.527, 95% PI = 0.126 – 1.002) did not include zero within its 95% probability interval (PI), and it was selected to be included in 60% of the model iterations (Table 5). Thus, the weight of evidence, though weak, was for a final model which only included a term for platform[9]. Latitude and longitude had

[6] All default values were used in the interpolation selection process with the exception that the number of neighboring points used in the estimation was raised from the default of 5 to 50 (equivalent to approximately 10 schools) in an effort to capture broad regional patterns instead of local, likely ephemeral, heterogeneities.

[7] The metric was calculated for the observed samples, and then each sample set was randomized with respect to pregnancy while keeping the proportion female the same as the observed. The resulting permutation tests were constructed on 20,000 replicates, and the significance of the spatial variation in proportion female was tested against what would be expected at random given the sampling geographic

[8] Various blubber progesterone levels were assessed as threshold criteria to differentiate pregnant from non-pregnant individuals to illustrate the marginal effect that this has on pregnancy determination and the resulting proportion pregnant data. This is important because there is some evidence that the biopsy process itself may alter the composition of the blubber: Ryan, C., B. McHugh, I. O'Connor, and S. Berrow. 2012. Lipid content of blubber biopsies is not representative of blubber in situ for fin whales (Balaenoptera physalus). Marine Mammal Science 29: 542–547.

[9] Remember if a factor is included in more than 50% of the iterations then the weight of evidence is for its inclusion; however at 60% inclusion rate there are still 40% of the iterations without this factor included.

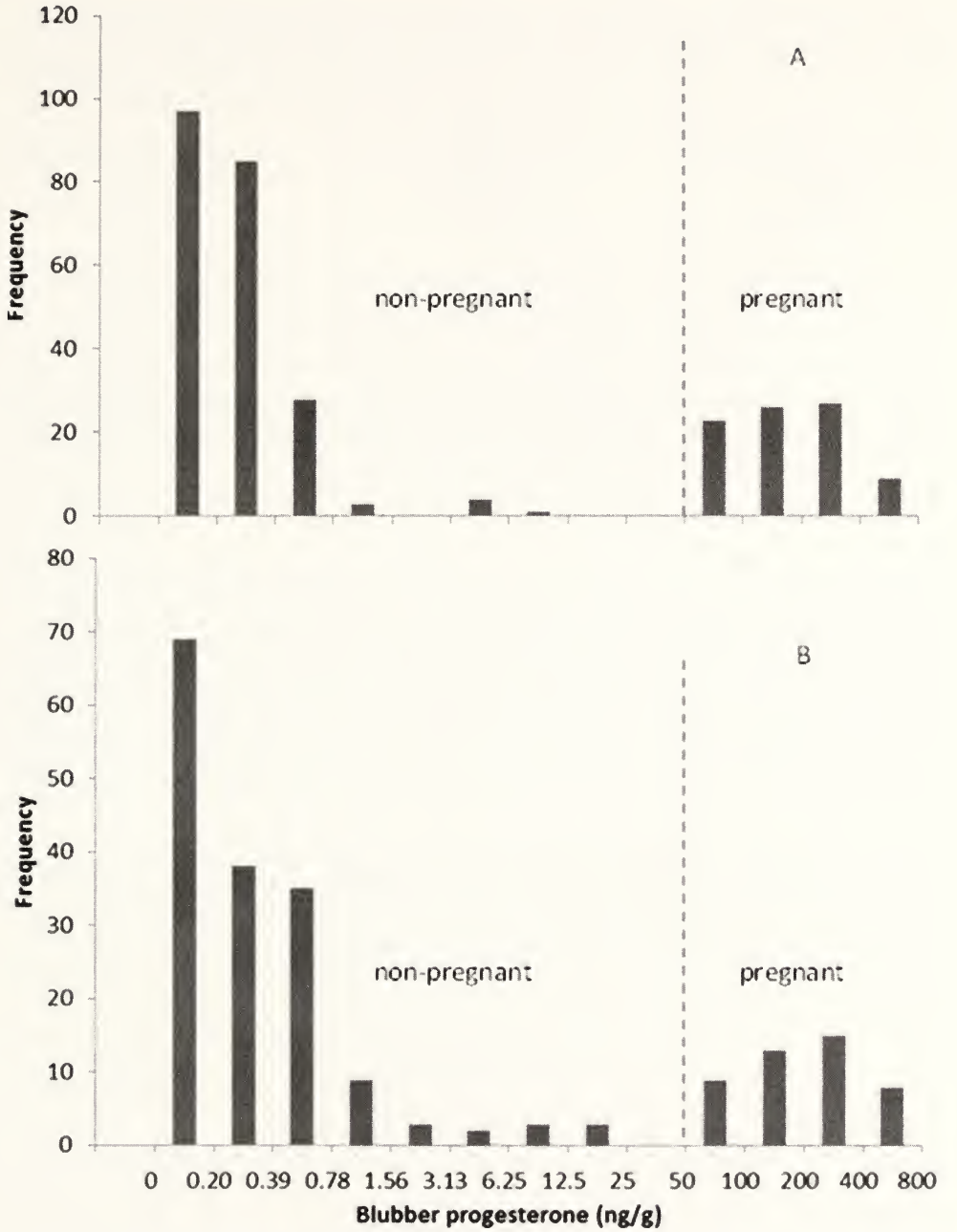


Fig. 1. *D. capensis*. Frequency distribution of blubber progesterone concentrations for *D. capensis*. (A) and *D. delphis* (B) biopsies. The abscissa is scaled via power function $x^2$to better visualize the two groups associated with each assessed pregnancy state.

less than majority support for inclusion, but like the evidence for platform, the statistical support was equivocal for both. There was no evidence for including biopsy order or school size for *D. capensis*. For *D. delphis*, latitude and longitude were strongly related to the proportion pregnant, as the posterior distributions for these coefficients (conditional

Table 2. Mean blubber progesterone values for nominally pregnant and non-pregnant females. Pregnancy status was determined using the 50 ng of progesterone per gram of tissue threshold value.

| | Meanq blubber progesterone (ng/g) ± SE | |
|---|---|---|
| Nominal pregnancy status | *D. capensis* | *D. delphis* |
| Pregnant | 241.9 ± 25.5 | 208.8 ± 15.4 |
| Not pregnant | 1.01 ± 0.28 | 0.671 ± 0.19 |

upon their inclusion in the model) were much greater than zero (latitude = 1.59, 95% PI = 0.904 – 2.35, increasing from south to north; longitude = 1.83, 95% PI = 1.12 – 2.60, increasing from west to east), and they were incorporated into 99.9% and 100.0% of the model iterations respectively (Table 5). For *D. delphis* there was additional strong support for inclusion of school size, which had a negative relationship with proportion pregnant. The other factors, platform and biopsy order, showed either equivocal or no evidence of a relationship with proportion pregnant (Table 5).

### *Tandem Biopsy Sampling*

Based on samples collected during the Tandem Biopsy Sampling, we did not find evidence of differences in the percent of dolphins pregnant between platforms (*D. capensis*: RHIB = 12.0% (6/50); research vessel = 23.9% (11/46)[9]; *D. delphis*: RHIB = 21.3% (13/61), research vessel = 22.0% (11/50)) (Table 6). For the 96 *D. capensis* biopsies, there is a 59.8% ($B_{10}$ = 1.49) probability that biopsy samples from the ship produced a higher proportion of pregnant females than biopsies from the RHIB (Figure 4). For the 111 *D. delphis* biopsies, the probability is 57.2% ($B_{10}$ = 1.34) that a higher proportion of pregnant females are obtained from the ship than the RHIB (Figure 4). Though the

Table 3. The number of biopsies obtained from known female (based on sexing) dolphins (*D. capensis* or *D. delphis*) that were assayed for pregnancy state and the resulting proportion identified as pregnant based on progesterone levels. The categories include all biopsies and the subsets taken from each vessel platform. A proportion of each of these samples was from the Tandem Biopsy Sampling operations in which, for a given school, biopsies were taken from one vessel platform (i.e., rigid-hull inflatable boat [RHIB] or ship) and then the other.

| | Species | |
|---|---|---|
| | *D. capensis* | *D. delphis* |
| **ALL BIOPSIES** | | |
| Total females biopsied/sexed | 204 | 303 |
| % pregnant | 22.1% | 28.1% |
| All biopsies from RHIB | 58 | 73 |
| % pregnant | 10.4% | 19.2% |
| All biopsies from ship | 146 | 230 |
| % pregnant | 26.7% | 30.9% |
| **TANDEM BIOPSY SAMPLING** | | |
| Tandem trials/schools | 10 | 8 |
| Tandem biopsies from RHIB | 50 | 61 |
| % pregnant | 0.120 | 0.213 |
| Tandem biopsies from ship | 46 | 50 |
| % pregnant | 0.239 | 0.220 |

Table 4. The percent pregnant as a function of the blubber progesterone criterion delineating pregnancy status. This table illustrates the limited change of the percent pregnant under different threshold criteria between 30 to 70ng/g.

| | Percentage of females that are pregnant | |
|---|---|---|
| Pregnancy criterion threshold | *D. capensis* (n=207) | *D. delphis* (n=303) |
| 30 ng/g | 21.7% (n=45) | 28.1% (n=85) |
| 40 ng/g | 21.7% (n=45) | 28.1% (n=85) |
| 50 ng/g | 21.7% (n=45) | 28.1% (n=85) |
| 60 ng/g | 21.3% (n=44) | 27.7% (n=84) |
| 70 ng/g | 20.8% (n=43) | 26.7% (n=81) |

overall percentage point differences between platforms are much greater for *D. capensis* than for *D. delphis*, neither show any evidence that one platform yields a disproportionate number of pregnant female biopsies when analyzed in a paired platform manner[10]. Note this finding is in contrast to that found in the model averaging results which are discussed further below.

### *Spatial Patterns of Pregnancy*

Figures 5 and 6 show the geographic distributions and inverse distance-weighting interpolations of the proportion pregnant for both species. The Ripley's K analysis indicated that pregnant female *D. capensis* were more clumped than would be expected at random, at distances greater than 18.5km (10nmi) and less than 139km (75nmi) (Figure 7) and again above 185km (100nmi) and less than 741km (400nmi). We found that pregnant *D. delphis* were clumped between 93 and 278km (50 and 150nmi: Figure 8). These results suggest that there were areas in which pregnant females were disproportionately more prevalent compared with other areas. Moreover, for *D. capensis* there were two scales of clumping, indicative of both tight regional aggregations and broad inter-regional areas of elevated pregnancy rates, and for *D. delphis* there was one dominant regional aggregation where pregnancy rate was high which was in a spatial scale between the two found for *D. capensis*.

When comparing biopsies from the three geographic strata, we found slightly different results for each species using the difference-of-proportion Bayesian statistical test (again akin to a Student's t-test). The lowest percent pregnant for both species were found north of Point Conception (*D. capensis* = 0.00% (n = 8), *D. delphis* = 8.33% (n = 24)), while the highest percent pregnant was in the Southern California Bight for *D. delphis* (*D. capensis* = 20.6% (n = 155), *D. delphis* = 33.5% (n = 224)), and in Baja, Mexico for *D. capensis* (*D. capensis* = 34.1% (n = 41), *D. delphis* = 14.5% (n = 55)). The only statistical comparison that was not notably different was for *D. delphis*, between north of Point Conception and Baja California, Mexico (Table 7).

[10] For *D. capensis* this may seem an unlikely outcome, but the large disparity in proportion pregnant from the overall count stems from the fact that female biopsies were not evenly distributed between the platforms, and the greatest inequity in female biopsy numbers come from schools in which no pregnant animals were obtained from either platform. For example, though 0/9 from the RHIB is the same percent as 0/2 from the research vessel, those from the RHIB have a greater impact on the overall denominator than those from the research vessel.

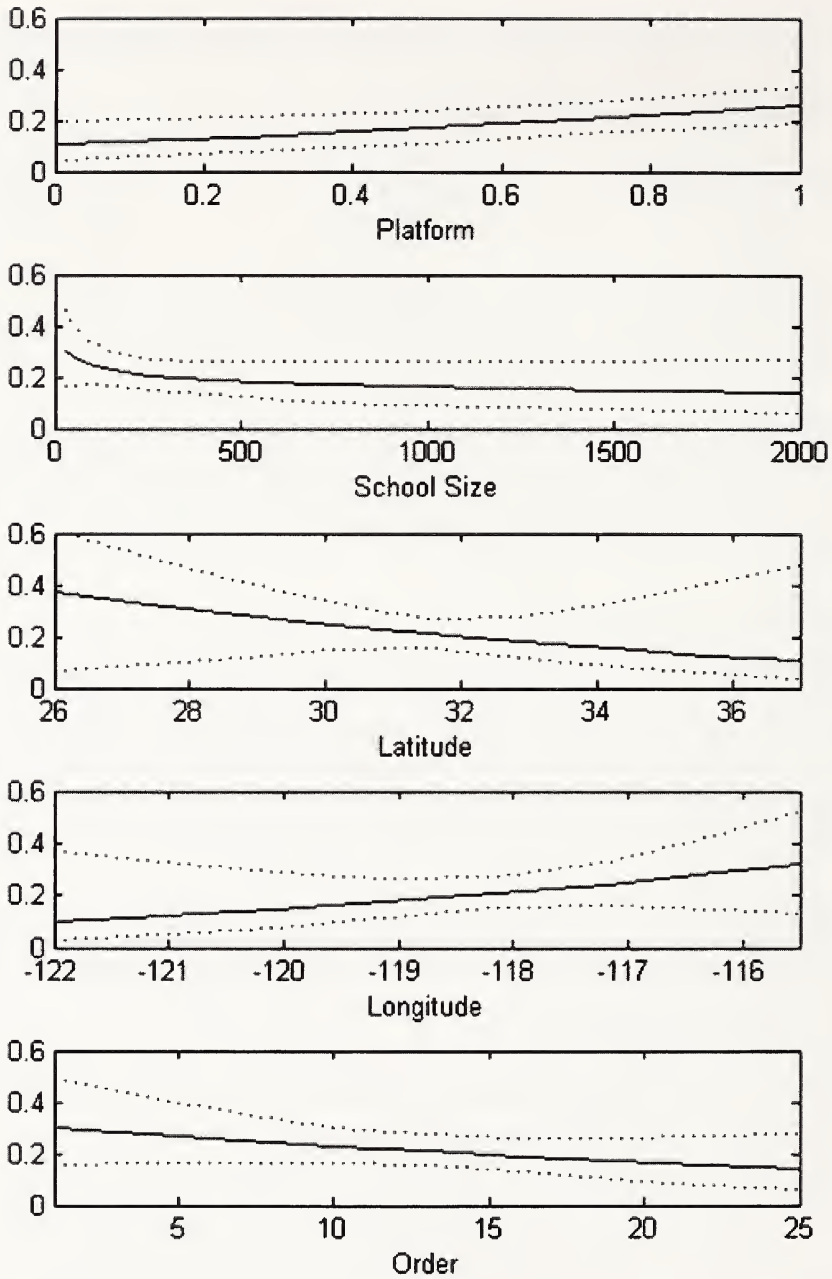


Fig. 2. *D. capensis*. Model-averaged marginal effects of platform, school size, latitude, longitude, and biopsy order, on proportion pregnant of female biopsy samples. Solid black lines: estimated marginal additive relationship, centered on mean value. Dashed black lines denote 95% probability envelope on the marginal effects. Platform value of "0" denotes the rigid-hull inflatable boat (RHIB) and "1" denotes the ship.

Seasonal differences in the proportion of pregnant females were evident between research cruise Legs 1 (early autumn) and 3 (late autumn) in *D. delphis* but not in *D. capensis* when restricting the area of both legs to their overlap in the inner Southern California Bight, the area designated as "Southern California" in Figure 6. For *D.*

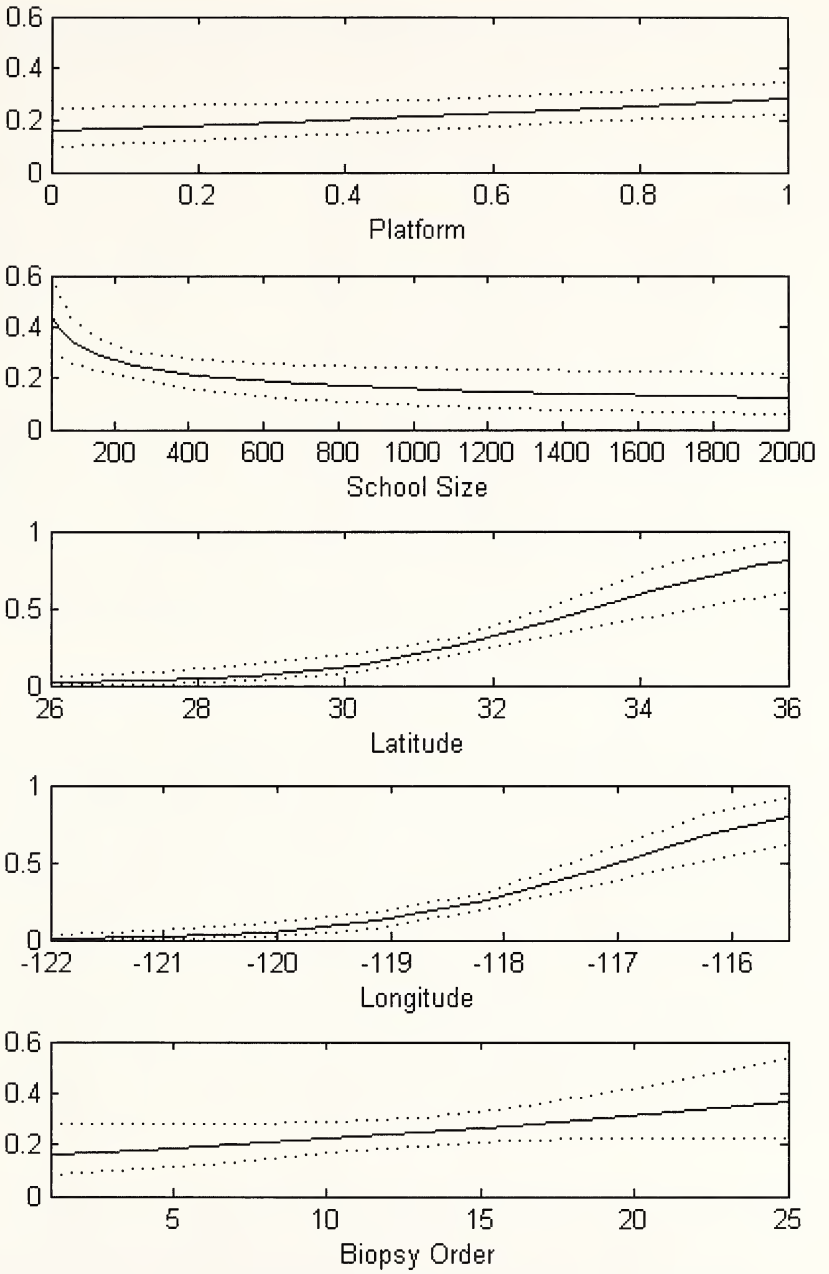


Fig. 3. *D. delphis*. Model-averaged marginal effects of platform, school size, latitude, longitude, and biopsy order on proportion pregnant of female biopsy samples. Solid black lines: estimated marginal additive relationship, centered on mean value. Dashed black lines denote 95% probability envelope on the marginal effects. Platform value of "0" denotes the rigid-hull inflatable boat (RHIB) and "1" denotes the ship.

*capensis* the percent pregnant values were 21.4% (n = 98) and 19.3% (n = 57) for Leg 1 (early autumn) and Leg 3 (late autumn) respectively, yielding little to no support for a change in pregnancy composition ($p_{1>3}$ = 0.664 ($B_{10}$ = 1.97)) over this period. However,

Table 5. Model averaged coefficients for factors associated with the proportion pregnant, median and 95% probability interval values. % selected: percent of the iterations that each factor was selected to be included in the final model.

| | | Coefficient estimates | | | |
|---|---|---|---|---|---|
| Species | Factor | 2.5% | Median | 97.5% | % selected |
| *Delphinus capensis* | | | | | |
| | platform | **0.126** | **0.527** | **1.002** | **60.2%** |
| | latitude | −0.874 | −0.399 | 0.621 | 39.4% |
| | longitude | −0.388 | 0.419 | 1.038 | 42.7% |
| | order | −0.639 | −0.242 | 0.135 | 9.3% |
| | school size | −0.600 | 0.248 | 0.116 | 10.8% |
| *Delphinus delphis* | | | | | |
| | platform | −0.075 | 0.365 | 0.681 | 43.8% |
| | latitude | **0.904** | **1.594** | **2.348** | **100.0%** |
| | longitude | **1.117** | **1.825** | **2.600** | **99.9%** |
| | order | −0.046 | 0.272 | 0.611 | 13.9% |
| | school size | **−0.749** | **−0.435** | **−0.143** | **72.5%** |

we found strong evidence for a decrease in percent pregnant in *D. delphis* ($p_{1>3}$ = 0.983 ($B_{10}$ = 58.4)) between early and late autumn with 38.8% (n = 133) pregnant during Leg 1 dropping to 25.3% (n = 91) during Leg 3.

## Discussion

Overall, the small differences we observed in percent pregnant in the two species are not unexpected given the marked similarities in their behavior, ecology, and overall biology (Heyning and Perrin 1994). However, our survey encompassed the entire outer coast (i.e., outside the Gulf of California) range of *D. capensis* but only the eastern fraction of the range of *D. delphis* in the study region and is therefore less likely to be representative of the population of the latter species (Chivers et al. 2010). If the more western, un-sampled section of the *D. delphis* range contained a substantially larger or smaller percent of pregnant females, then we might have found greater differences in pregnancy rates between the two species. We note this because of 1) the strong geographic pattern in pregnancy in the sampled *D. delphis* indicating that schools sampled further west tended to have a lower proportion pregnant, and 2) the fact that in a previous study (Kellar et al. 2012) examining these same biopsy samples we found large differences in sex

Table 6. Results from the Tandem Biopsy Sampling comparison. Biopsies were collected from both the small RHIB and the large research vessel from the same schools. The difference in the fraction pregnant between these pairings is listed as mean difference in the proportion pregnant (with 95% probability interval). The number of the paired tandem trials and the aggregate proportion pregnant per platform is also reported.

| | Proportion female RHIB (n) | Proportion female Ship (n) | # of tandem trials | Mean difference proportion female (95% PI) | Bayes Factor ($B_{10}$) |
|---|---|---|---|---|---|
| *D. capensis* | 0.120 (50) | 0.239 (46) | 10 | 0.057 (−0.085 to 0.190) | 1.49 |
| *D. delphis* | 0.233 (61) | 0.220 (50) | 8 | 0.024 (−0.121 to 0.161) | 1.34 |

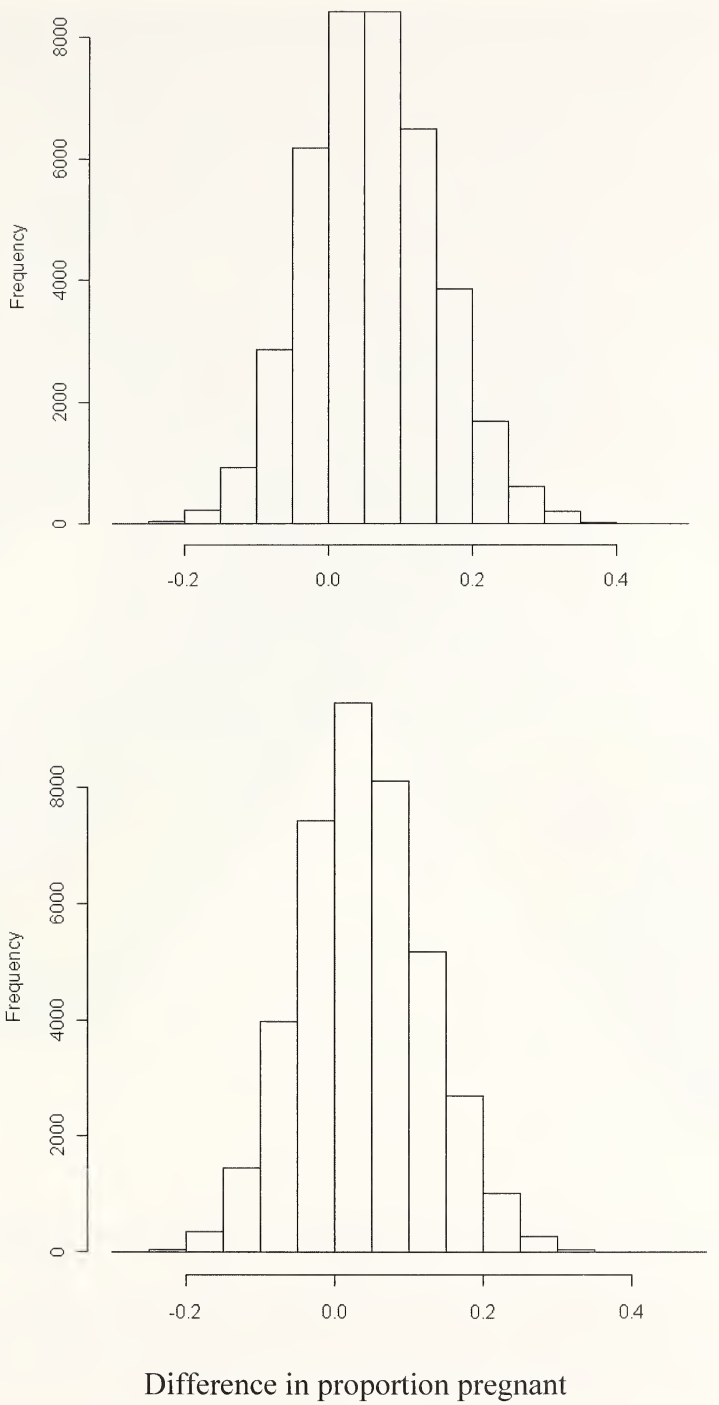


Fig. 4. Posterior probability distributions of the difference between the proportion of pregnant values for each tandem pairing (vessel: rigid-hull inflatable boat and ship) representing both species; *D. capensis* (top) and *D. delphis* (bottom).

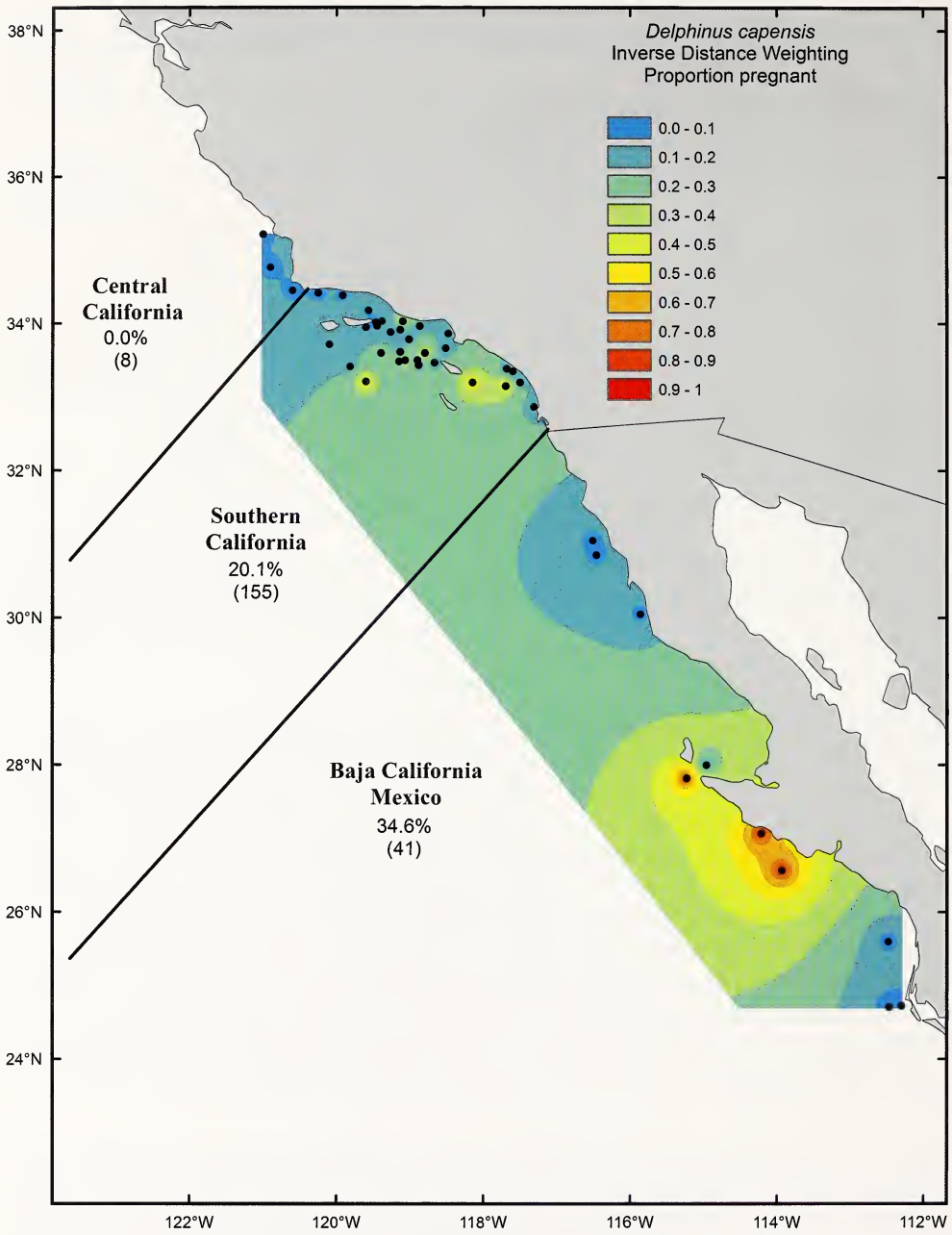


Fig. 5. *D. capensis*. Inverse distance weighted interpolation map of the proportion pregnant as measured from biopsies (locations denoted by dark circles). Diagonal lines demarcate boundaries separating three geographic strata: Central California, Southern California, and Baja, Mexico. In each stratum the proportion female and sample size (in parenthesizes) are indicated.

composition (*D. capensis* = 40.9% female, *D. delphis* = 66.1% female) with strong geographic relationships. Though this latter point has no direct bearing on the percent pregnant measurements made here, it does show that there are demographic parameters that are not similar between these two species.

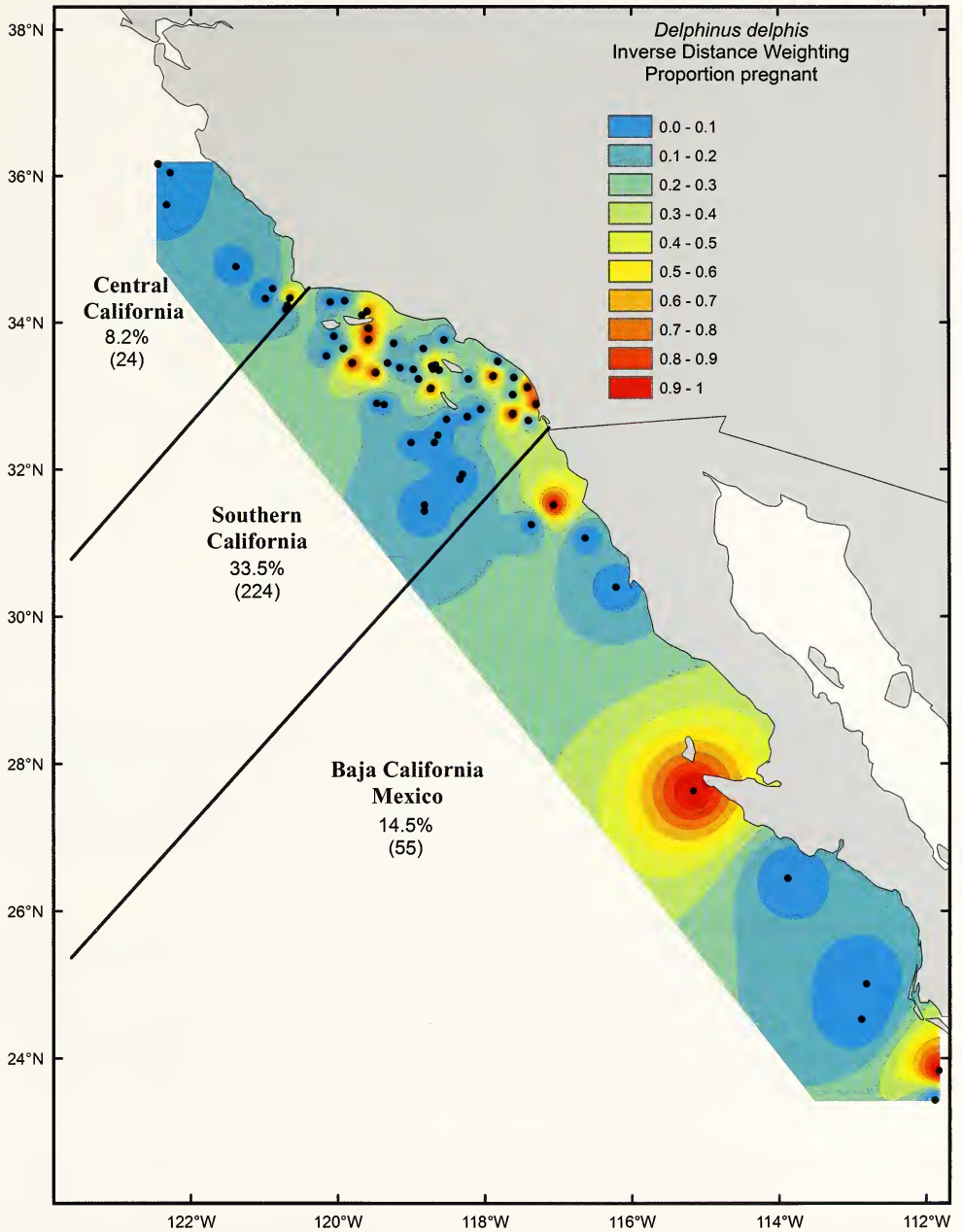


Fig. 6. *D. delphis.* Inverse distance weighted interpolation map of the proportion pregnant as measured from biopsies (locations denoted by dark circles). Diagonal lines demarcate boundaries separating three geographic strata: Central California, Southern California, and Baja, Mexico. In each stratum the proportion female and sample size (in parenthesizes) are indicated.

It was difficult to compare our estimates of the percent pregnant in each species (22.1% and 28.1% for *D. capensis* and *D. delphis* respectively) to other studies where estimates were derived from examinations of full carcasses for two reasons: 1) our operational restrictions prevented sampling of mothers with calves and calves, and 2) our inability to

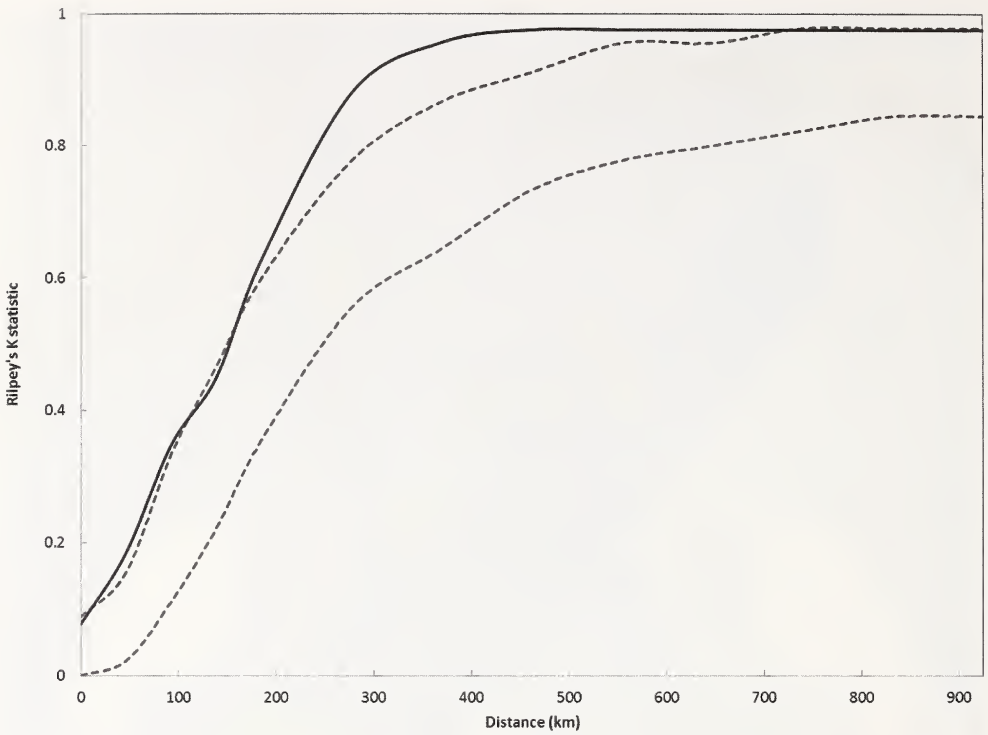


Fig. 7. Results of spatial pattern analysis of the distribution of pregnant female *D. capensis* dolphins relative to all *D. capensis* females sampled using Ripley's K statistic. The function K(d) was calculated for each 20-nmi interval (0–100nmi) and 50-nmi interval (>300nmi). The derived sample statistic K(d)/ $n_{pregnant}$ from the observed data was plotted against distance (solid line). The dotted lines represent the 95% confidence envelope for the total spatial randomness (the null distribution). The envelope was derived by permuting (10,000 simulations/distance interval) Ripley's K for the entire set of sampling sets.

reliably distinguish female maturity status from biopsy samples (most pregnancy metrics in the literature are based on the proportion of mature females that are pregnant). Thus, because we know much more about the life-history characteristics of each of the carcasses than the biopsied animals, we can more directly convert parameter estimates from these life-history studies for comparisons to those we have generated from the biopsy data. Perhaps the best comparable metric from the carcass data is:

$$p_{sp} = \frac{P_o}{P_o + R + Im - 0.5L - 0.5P_l} * 100 \quad (2)$$

where $p_{sp}$ is the percent of solely pregnant females out of all non-lactating females, $P_o$ is the number of animals that are pregnant and not lactating, $R$ is the number of adult females that are resting (i.e., neither lactating nor pregnant), $Im$ is the number of immature females, $L$ is the number of non-pregnant lactating females, and $P_l$ is the number of simultaneously pregnant and lactating females. By not including mothers (those lactating) and subtracting out the number of female calves (i.e., "$-0.5L-0.5P_l$") in this metric, we can more appropriately make a comparison with the biopsy samples, which are specifically designed not to include mothers and calves. Deriving this metric from the three most recent carcass-based life-history studies of *D. delphis* yields $p_{sp}$ values of 12.9% (n = 492) (derived from Murphy et al. 2009) for the eastern North Atlantic,

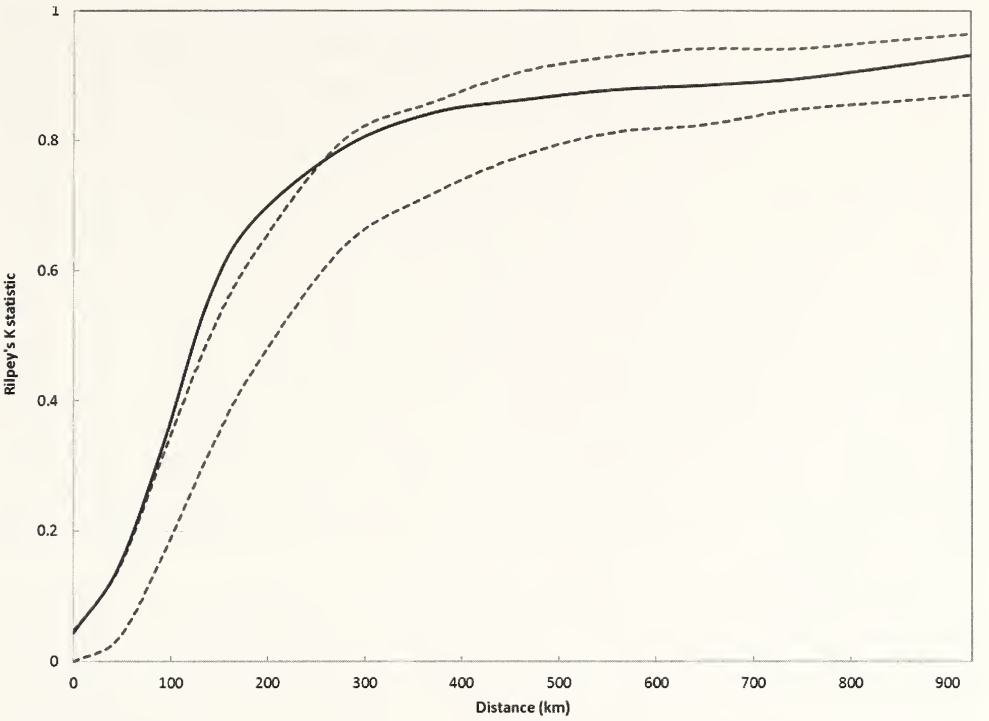


Fig. 8. Results of spatial pattern analysis of the distribution of pregnant female *D. delphis* dolphins relative to all *D. delphis* females sampled using Ripley's K statistic. The function K(d) was calculated for each 20-nmi interval (0–100nmi) and 50-nmi interval (>300nmi). The derived sample statistic K(d)/ $n_{pregnant}$ from the observed data was plotted against distance (solid line). The dotted lines represent the 95% confidence envelope for the total spatial randomness (the null distribution). The envelope was derived by permuting (10,000 simulations/distance interval) Ripley's K for the entire set of sampling sets.

22.5% (n = 22) (derived from Westgate and Reed 2009) for the western North Atlantic, and 21.9% (n = 379) (derived from Danil and Chivers 2007) for the eastern tropical Pacific. Our $p_{sp}$ value for *D. delphis* (28.1%) in this study was higher than these, while the *D. capensis* value (22.1%) was comparable to the two higher carcass-based estimates.

We also implemented a similar conversion using estimates of the proportion of calves in a school (derived from counts on aerial photographs) to obtain suitable values for

Table 7. Comparison of the proportion pregnant between three regions in the study area. Listed are the median estimates from the posterior probability distributions of the northern area in each comparison exhibiting a smaller proportion pregnant than the southern area and the associated Bayes Factors. The lowest percent pregnant for both species were found north of Point Conception, while the highest percent pregnant was in the Southern California Bight for *D. delphis*, and in Baja, Mexico for *D. capensis*. The only statistical comparison that was not notably different was for *D. delphis*, between north of Point Conception and Baja California, Mexico.

| | *Delphinus capensis* | | |
|---|---|---|---|
| *Delphinus delphis* | N. of Pt. Conception | S. California Bight | Baja, Mexico |
| N. of Pt. Conception | n/a | 0.991 ($B_{10}$ = 106.1) | 0.998 ($B_{10}$ = 517.1) |
| S. California Bight | 0.999 ($B_{10}$ = 665.7) | n/a | 0.978 ($B_{10}$ = 44.85) |
| Baja, Mexico | 0.857 ($B_{10}$ = 5.99) | 0.997 ($B_{10}$ = 335.7) | n/a |

comparison to our biopsy data. This conversion required estimates of proportion of females in the sampled populations. Using data collected during the same survey we have obtained estimates for percent calves from aerial photography (Chivers et al. 2012) and percent female (via sexing of biopsies) (Kellar et al. 2012) for each species (*D. capensis*: percent female = 40.9% and percent calves = 4.5%; *D. delphis*: percent female = 66.1% and percent calves = 5.7%). These values translate into percent females-with-calf values of 11.0% and 8.6% for *D. capensis* and *D. delphis* respectively. In order to compare these values to the percent pregnant from biopsies, we also need to adjust the biopsy data to compensate for the fact that we do not target mother calf pairs for biopsy. Under the assumption that for every calf present, 1.5 females are not available for biopsy (1.0 for each mother and 0.5 for each calf, assuming that every other calf is female), we estimate that 16.5% and 13.0% of all females are not available for biopsy for *D. capensis* and *D. delphis* respectively for our biopsy sample set. Therefore, when we correct for this discrepancy in the females available for each data set (aerial images versus biopsy samples), the estimates decrease to 18.4% and 24.4% for the biopsied *D. capensis* and *D. delphis* respectively. These values remain substantially greater than the females-with-calf values (11.0% for *D. capensis* and 8.6% for *D. delphis*) perhaps indicative of high perinatal mortality.

Clearly differences in the way that pregnancy rate and calving rate were measured could explain some of the difference in rates though this is difficult to assess. However, given the magnitude of these differences, we feel it is likely that additional factors play a more important role here. If perinatal mortality is responsible for the disparity between pregnancy and calf production, it possibly could be linked to anomalous oceanographic conditions observed in the California current ecosystem in the months preceding our survey (May-August 2009). Waters off California were anomalously warm, and upwelling indicators were at values lower than those observed in the previous 40 years (Melin et al. 2010). This event was thought to be a major contributing factor in the massive California sea lion (*Zalophus californianus*) mortality (e.g., ~80% pup mortality on San Miguel Island) observed within this area in 2009 (Melin et al. 2010). There is evidence that the direct cause was a radical shift in prey composition and availability associated with these anomalous conditions. Given the overlap in prey between these sea lions and common dolphins, it would be reasonable to expect some impact on the dolphins as well (Heyning and Perrin 1994, Melin et al. 2010). Higher calf mortality would not only lead to fewer calves, but it could also allow mothers who lost calves to become pregnant again sooner, thereby increasing the number of pregnancies, as lactation has an inhibitory effect on mammalian estrous cycling (Pineda 2003). We speculate that the lingering effects of this event may also be responsible for the decrease in observed pregnancy rates from Leg 1 (September) to Leg 3 (November) of the survey in *D. delphis* in the California Bight.

### *Spatial Patterns in Pregnancy*

Pregnant animals were disproportionately aggregated in specific locations for both species. For instance, the more southern areas of the Southern California Bight had higher pregnancy rates for both species; this was particularly true for *D. delphis* for which ~75% of all sampled pregnant animals were in the 220-kilometer stretch southeast of San Miguel island to the US/Mexico border, within 100 kilometers of shore. *D capensis* had another area of high pregnancy between Cedros Island and Magdalena Bay. Both areas' oceanographic conditions are characterized by counter currents and semi-permanent

eddies creating tongues of warm sea surface temperature adjacent to strong upwelling areas (Soto-Mardones et al. 2004, Checkley and Barth 2009). These conditions promote enhanced growth and spawning of pelagic schooling fishes such as sardine, anchovy, and hake, which are all prey species of common dolphins (Hewitt 1981, Checkley and Barth 2009). It is not uncommon for mammals to segregate by demographic or reproductive condition by selecting habitats that can meet their specific nutritional requirements (Seagle and McNaughton 1992, Labisky and Fritzen 1998, Bowyer 2004, Millspaugh et al. 2004, Ciuti et al. 2006). Pregnant females, especially during mid- to late-gestation, experience large increases in energy requirements (Millar 1977, Jonsson et al. 1995, Reynolds and Kunz 2000) and changes in dietary needs that can prompt movement to more productive or more nutritionally appropriate habitats (Bonenfant et al. 2002). However, we know that the nutritional requirements of lactation are even higher (Hadjipieris and Holmes 1966, Millar 1975, 1977, Bowen et al. 2001); in some mammals the difference is as much as three times as great (Millar 1977). If nutrition is a driver for reproductive partitioning or differential location selectivity, we would not necessarily expect only pregnant animals to be disproportionately occupying the areas of highest nutritional output or highest prey concentration; lactating females would be subject to the same drive. This explanation presupposes two things. First, it assumes that there is some drawback to these areas such that when a female is not either pregnant or lactating she would be more likely to move to an area of more limited nutritional resources; otherwise one would expect that all animals, regardless of reproductive condition, would seek out areas of high productivity. Second, it also assumes that nutritional requirements are the primary drivers of spatial distribution; others include predation avoidance, thermoregulation, human activity aversion (e.g., pollution, fishery interactions, and auditory perturbations).

*Sampling Bias*

The evidence for differences in bowriding behavior between pregnancy states is equivocal for both species. Our interpretation assumes that biopsies from the RHIB are more likely to be taken randomly with respect to pregnancy status, because the acquisition of biopsies from this platform is less dependent on bowriding behavior than acquisition from the research vessel. We found that the proportion of pregnant females sampled from the research vessel was greater than from the RHIB in both species. Though the weight of evidence supports the inclusion of platform as a predictor variable for pregnancy in *D. capensis* but not in *D. delphis*, the evidence was not definitive in either case. When the paired tandem vessel sampling was examined, there was no relationship between platform and pregnancy in either species, though the sample sizes for these comparisons were low such that we may not have had sufficient power to address this question in the tandem structure. In a previous study examining sex-linked bowriding differences we found a similar pattern (Kellar et al. 2013). In the general linear model, there was evidence that male *D. capensis* were more likely to be sampled than females from the bow of the ship than from the RHIB, but in the tandem analysis there was no evidence of differences between platforms (the sample size in Kellar et al. 2013 was larger than in the present study). In this same study, neither analysis yielded evidence of differences in sex-ratio for *D. delphis*.

The other way we examined the bowriding behavior with respect to biopsy operations was by examining the relationship between pregnancy and sample order. We found very weak or no evidence of such a relationship in either species. This finding is not consistent with the

supposition that animals of one pregnancy state or the other becomes disproportionately frightened, wary, or disinterested in bowriding the longer biopsy operations continue. Again, the (Kellar et al. 2013) study had similar results to this study when examining sex-ratio instead of pregnancy. They found no evidence that one sex disproportionately become more wary of or attracted to biopsy operations compared with the other.

## Conclusions

As cetologists continue to use biopsies to assess pregnancy patterns, they should be cognizant of the potential biases associated with biopsies of bowriding animals. However, the common dolphin pregnancy data analyzed in this study provided a series of findings that begin to illuminate population-level aspects of pregnancy patterns. Pregnancy estimates from the biopsies were comparable to those derived from full specimens, suggesting that they may be usable for future population comparisons. Differences between the two species were observed in the factors that were correlated with percent pregnant. Pregnancy was not uniform geographically, but rather there were concentrations of high pregnancy rates, perhaps in areas more beneficial for gestation. Finally, there were results consistent with a hypothesis of a period following a high natal mortality event, perhaps an indication of the effects of anomalous oceanographic conditions. Thus, this study demonstrates the utility of concentrated biopsy sampling and the techniques employed to detect pregnancy, as it would not be possible to obtain comparable data across entire populations in such a short time frame solely from bycaught and stranded specimens.

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# Responses of Small Mammals to Wildfire in a Mixed Conifer Forest in the San Bernardino Mountains, California

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*Abstract.*—Wildfires are becoming more prevalent in montane conifer forests of the San Bernardino Mountains of southern California. The effects of fire on stand structure and composition of these forests has been extensively studied but there are far fewer studies on how wildfires affect the fauna. For five years after a wildfire in 2007, we live-trapped small mammals in three burn types: unburned, moderate-severity and high-severity. A primary objective of this study was to document the response of the small mammal community to high-severity fire. Pinyon mice were consistently more abundant in unburned forests and declined by 69–76% between unburned forests and moderate-severity and high-severity burns. In contrast, deer mice responded positively to fire. Their numbers increased by 72%–87% between unburned forests and moderate-severity and high-severity burns. Compared to unburned forests, chipmunk numbers were 43%–64% lower in moderate and high-severity burns. California ground squirrels were unaffected by either severity. Using ordination analysis, we examined the distributions of the four small mammal species in relationship to stand structure and microhabitat variables that changed after fire. When the three burn types were analyzed together, small mammal composition was significantly related to burn type (unburned vs. high-severity), years-after-fire, litter cover and cover of bare ground. When the moderate and high-severity burn types were analyzed without unburned grids, four variables were significant: years-after-fire, rock outcrop cover, bare ground cover, and the combined covers of oak resprouts and shrubs.

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Montane yellow pine (*Pinus ponderosa* and *P. jeffreyi*) and mixed conifer forests in the San Bernardino Mountains (SBM) of southern California have undergone significant changes in tree species composition and structure since the advent of fire suppression beginning around 1910 (Minnich et al., 1995). Prior to suppression, frequent surface fires (intervals of 10 to 14 years) cleared the understory of shrubs, coarse woody debris, saplings and pole-sized trees (McBride and Laven, 1976). Stand-replacing fires were uncommon and usually burned small patches totaling no more than 5% of the forested area (Minnich, 2007). This regime of high-frequency, low-intensity fires perpetuated open forests dominated by large-diameter, shade-intolerant conifers such as Jeffrey (*Pinus jeffreyi*) and ponderosa pines (*P. ponderosa*).

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Fire suppression in the SBM contributed to a sharp increase in tree densities, especially in the smaller size classes (Minnich et al., 1995). In some forests the proportions of fire-sensitive, shade-tolerant species such as white fir (*Abies concolor*) and incense cedar (*Libocedrus decurrens*) increased in both the understory and overstory at the expense of the shade-intolerant pines. Overall, the increase in tree density has been accompanied by higher tree mortality and a concomitant accumulation of coarse woody debris (Minnich, 2007).

Despite an overall increase in fuel loading in these forests, fire suppression has continued to be highly effective in extinguishing fires through the 20$^{th}$ century. However, beginning in 2003 there was an abrupt change in both the size and severity of fires in southern California conifer forests (Franklin et al., 2006; Goforth and Minnich, 2008; Keeley et al., 2009). Between 2003 and 2009 approximately 23,500 ha of montane conifer forests burned in the Transverse and Peninsular Ranges; much of the total was in stand-replacing fires (Keeley et al., 2009). Climate-change scenarios suggest that conifer forests of the SBM will continue to experience larger, more severe fires as the regional climate becomes warmer and drier (Westerling and Bryant, 2008; Stephens et al., 2013).

The SBM support the largest island of coniferous forests in the Transverse Ranges or Peninsular Ranges in southern California and yet, while much has been written about fire and vegetation, there are only two studies on the response of vertebrates to wildfires in these forests: carnivores (Borchert, 2012) and California spotted owls (*Strix occidentalis occidentalis*, Lee et al., 2013). Moreover, there are no post-fire small mammal studies in the SBM compared to at least six studies in the Sierra Nevada Mountains. Nevertheless, five of the Sierra Nevada studies focus on the effects of thinning and prescribed burning on small mammals (Meyer et al., 2005; Monroe and Converse, 2006; Meyer et al. 2007; Amacher et al. 2008; Maguire et al., 2008) while only one examines the effects of a wildfire (Roberts et al., 2008).

Because the severity of wildfires in the SBM is expected to increase in the coming decades (Westerling and Bryant, 2008), land managers need to better understand the responses of the fauna to fire, especially high-severity fire (Bond et al., 2012). Therefore, the goals of this study were to (1) to document the response of small mammals to moderate and high-severity fire in a southern California conifer forest and (2) to describe microhabitats favored by small mammals in burned and unburned forests.

## Materials and Methods

### *Study Area*

The study was conducted in a 415-ha area approximately 2 km northwest of Fawnskin, California (34°16.51′N, 116°58.18′W) in the SBM. The study area ranges in elevation from 2068–2263 m. Topography is flat to gently undulating (slopes average $< 10°$) with some parts dissected by the main drainage of Grout Creek and its tributaries. Soils are shallow to moderately deep loamy-coarse sands derived from granite. Jeffrey pine-white fir /California black oak (*Quercus kelloggii*) woodlands and forests dominate the study area. Prominent understory shrubs include mountain whitethorn (*Ceanothus cordulatus*), greenleaf manzanita (*Arctostaphylos patula*), rubber rabbitbrush (*Ericameria nauseosa*) and big sagebrush (*Artemisia tridentata*). Hundreds of mounding rock outcrops are scattered throughout the study area, ranging in size from 500 $m^2$ to 1.5 ha.

Climate of the study area is Mediterranean which is characterized by cold, wet winters and warm, dry summers. Average annual precipitation recorded at the nearest weather station (Big Bear Lake, CA) is 566 mm, most of which falls as snow from November to

April. Average annual precipitation from the 2008 to August 2012 was 524 mm. Four years of the study were below the long term average precipitation and one year (2010) was almost twice the long term average.

Evidence of late 19th and early 20th century logging in the form of stumps and decaying slash are still present in unburned areas but there are no records of wildfires in the study area in the century before the 2007 Butler 2 Fire which began on 14 September near Butler Peak. Sustained southwest winds of 40 km hour$^{-1}$ enlarged the burn area from 800 ha to 5670 ha in a 12-hour period. As the fire pushed northeast toward the desert, it became a stand-replacing fire although it produced a relatively narrow (0.5–1.0 km) moderate to moderate-high severity zone between unburned forests and those that burned at high-severity.

We selected three burn types for small mammal live-trapping. Four trapping grids were located in a 146-ha unburned area, four in the 100-ha moderate-severity burn and four in a 169-ha high-severity burn. Moderate severity is defined as tree basal area mortality from 40–60% while high-severity basal area mortality is >90% (Fontaine and Kennedy, 2012).

Within each of the three burn types we established four trapping grids. A grid consisted of two parallel transects with 11 traps per transect. Spacing between traps was 20 m and the transects were 20 m apart (Converse et al., 2006a). Thus, there were 4 grids (88 traps total) in each burn type and each covered 0.4 ha. In an attempt to capture the variability in stand structure, we located the grids haphazardly in each type. Rock outcrops were present in all the grids. Grids were located at least 65 m from roads and trails and were spaced a minimum of 300 m (mean 427 m) apart.

*Stand Structure and Microhabitat Sampling*

Within a 5-m radius (80 m$^2$) of each trap station we measured the diameter at breast height of all stems >5 cm for each tree species and noted whether they were alive or dead. We recorded overstory cover in the plot with a spherical densiometer but we did not separate live from dead cover (Table 1). Within a radius of 4 m (50.2 m$^2$) of the station center, we visually estimated cover of the variables listed in Table 1 and placed each estimate into one of seven percent cover classes: 0–1, 2–5, 6–15, 16–25, 26–50, 51–75 and 76–100. Midpoint values of each class were used in the analyses. Stand structure and microhabitat sampling was conducted on each grid at the end of every annual trapping session.

*Live-trapping*

We placed one extra-large (10.2 cm × 11.4 cm × 38.1 cm) Sherman live trap within 2 m of each station marker under vegetative cover or in close proximity to rocks, tree bases or coarse woody debris. Where natural cover was unavailable, wood shingles were used to shade exposed traps. Cotton batting was placed at the back of each trap for insulation, and a mixture of peanut pieces, walnut pieces and black oil sunflower seeds was provided as bait.

We trapped the 12 grids over a five-week period from late July through August for five years (2008–2012) after the fire. We trapped each grid for four consecutive nights (4 trap-nights). Traps were checked each morning before 10:00 hours. Captured individuals were identified to species, weighed, sexed and marked on the underside of the tail at the base with a permanent marking pen. We applied a different pen color for each capture day so that the capture history of each animal could be discerned from the color sequence. We

Table 1. Microhabitat and stand structure variables.

| Variable | Acronym | Description |
|---|---|---|
| Rock outcrop cover | Rock | Singular, connected rock mass |
| Diffuse rock cover | DifRock | Scattered, unconnected individual rocks |
| Bare ground cover | Bare | Exposed soil |
| Litter cover | Litter | Dead leaves, pine needles, bark pieces |
| Forb and grass cover | HerbCv | Herbaceous vegetation and grasses |
| Live shrub cover | LiveShrb | Green, living shrubs |
| Dead shrub cover | DeadShrb | Shrubs with no live foliage and dead branches |
| Black oak resprout cover | OakRsp | Post-fire, green basal resprouts |
| Canopy cover | Canopy | Overstory, living and dead foliage and branches |
| Coarse woody debris cover (<10 cm diameter) | CWD ≤10 | Twigs and small branches |
| Coarse woody debris cover (11–30 cm diameter) | CWD 11–30 | Larger branches |
| Coarse woody debris cover (>31 cm diameter) | CWD >30 | Logs |
| Conifer density | ConDen | Conifer stems in 80 $m^{-2}$ |
| Conifer basal area | ConBA | Conifer $m^2$ in 80 $m^{-2}$ |
| Oak stem density | OakDen | Oak stems in 80 $m^{-2}$ |
| Oak basal area | OakBA | Oak $m^2$ in 80 $m^{-2}$ |
| Total basal area | TotBA | $m^2$ basal area in 80 $m^{-2}$ |

identified individual animals using a combination of species, sex, weight, reproductive condition (pregnant or not, testes scrotal etc.) and tail markings (color sequence applied to the tail base).

Weight and pelage color were used to separate *Peromyscus* juveniles from adults and sub-adults; for both species of *Peromyscus* non-reproductive juveniles were < 16 g. We did not distinguish Merriam's chipmunks (*Neotamias merriami*) from obscure chipmunks (*N. obscurus*) so they were combined for the analyses. California ground squirrels (*Otospermophilus beecheyi*) and golden-mantled ground squirrels (*Callospermophilus lateralis*) were weighed in the traps but not handled. We used squirrel weights to identify the number of squirrels on each grid.

### *Statistical Analyses*

During the five year study, we trapped a total 60 grids (3 burn types × 4 replicates per burn type × 5 years). Because the number of individuals captured was not normally distributed for any of the species, we used negative binomial regression (log link function) to determine if the number of individuals captured on the grids were associated with two covariates: burn type and years-after-fire. Negative binomial regression (NBR) was employed because a relatively high proportion of grids had zero individuals resulting in a variance that exceeded the mean (Lindén and Mäntyniemi, 2011). For example, variance-to-mean ratios for the four species ranged from 2.1–9.4.

If abundance was significantly related to burn type in the NBR analysis, we determined which of the types was significant by analyzing pairs of burn types (unburned vs. moderate severity, unburned vs. high severity, and moderate vs. high severity). We compared two types by deleting one of the types and running NBR on the 40 remaining grids. For the analysis we used the function "glm.nb" in the MASS package of R as outlined by Zuur et al. (2009).

We employed canonical correspondence analysis (CCA, ter Braak, 1986; CANOCO software: ter Braak and Šmilauer, 2002) to investigate relationships between rodent species composition and environmental variables in each burn type. This technique has been used to analyze the role of microhabitat variables in small mammal studies in both burned (Simon et al., 2002) and unburned conifer forests (Copetto et al., 2006; Glennon and Porter, 2007; Kelt et al., 2013).

Canonical correspondence analysis is a direct gradient analysis technique that performs an iterative multiple regression between site scores (rodent captures) and environmental variables and identifies significant relationships between the two matrices. It produces eigenvalues that measure how much of the variation in site scores is explained by environmental variables. Canonical correspondence analysis assumes species have normal distributions along environmental gradients but is robust to moderate violations of normality (Palmer, 1993; ter Braak and Šmilauer, 2002).

We utilized captures (not individuals) of the following species for the CCA analysis: pinyon mice, deer mice, Merriam's and obscure chipmunks pooled and California ground squirrels. Three types of variables were analyzed in the CCA: (a) microhabitat, (b) stand structure, (c) years-after-fire and (d) burn type (unburned, moderate severity and high-severity) (Table 1). Burn type was coded as a dummy variable for the analyses and years-after-fire served as the time variable. Captures were log transformed for the analyses. Highly collinear variables identified by CANOCO were removed from the analysis.

Initially, we analyzed species and environmental variables for the three burn types together. Next, we analyzed each burn type separately to elucidate variables unique to each that may have been subsumed in the analysis of all three burn types. We first analyzed the unburned grids and then the burn types. Because significant variables in the analyses of the high- and moderate severity grids were similar, we combined these two types into a single analysis. All together we performed three CCAs: one on the three burn types together, one on the unburned grids and another on the moderate and high-severity grids combined.

We used the forward selection option in CANOCO 4.5 to identify significant ($p < 0.05$) variables. Statistical significance of each environmental variable was tested using a Monte Carlo permutation test (1000 permutations). The importance of each axis in the CCA was interpreted by its eigenvalue, percentage of the variance explained, species-environment correlations and weighted inter-set correlations, i.e. the correlations between the environmental variables and species ordination axes.

We used biplot diagrams to illustrate the relationship between the species and significant variables. In a biplot diagram, species are shown as points and environmental variables are represented by arrows. Species points and arrows jointly represent the species' distributions along each environmental variable (ter Braak, 1986).

## Results

### *Vegetation*

In the unburned grids 3% of the tree stems were dead. After the fire, the percentage of dead stems in the moderate-severity grids was 79.2% and in high-severity grids it was 99%. In the unburned grids 7.4% of the basal area was dead while basal area mortality reached 51.1% and 95% in the moderate-severity and high-severity grids, respectively. White fir and California black oaks showed the highest aboveground stem mortality in the burn areas (Table 2). Average stems $ha^{-1}$ of conifers and hardwoods for the unburned, moderate-severity and high severity grids were 97, 57.6 and 72.7, respectively.

Table 2. Changes in forest stand structure after the fire. PIJE is Jeffrey pine, ABCO is white fir, and QUKE is California black oak. Values are means ± 1 SD.

| Variable | Unburned | | Moderate severity | | High severity | |
|---|---|---|---|---|---|---|
| | Live | Dead | Live | Dead | Live | Dead |
| PIJE density (trees $ha^{-1}$) | 111.1 (18.8) | 0 | 8.9 (1.6) | 34.9 (11.4) | 3.5 (1.9) | 127.2 (22.4) |
| PIJE basal Area ($m^2ha^{-1}$) | 4.7 (1.2) | 0 | 7.5 (1.9) | 4.7 (1.9) | 0.8 (0.4) | 10.2 (2.3) |
| ABCO density (trees $ha^{-1}$) | 27.5 (7.5) | 4.3 (2.4) | 2.4 (1.9) | 41.2 (17.7) | 0 | 22.4 (2.4) |
| ABCO basal area ($m^2ha^{-1}$) | 0.8 (0.8) | 0.4 (0.4) | 0.8 (0.8) | 2.4 (1.2) | 0 | 1.2 (0.4) |
| QUKE density (stems $ha^{-1}$) | 232.4 (41.2) | 7.1 (0.8) | 9.8 (5.5) | 92.6 (23.5) | 0 | 128.7 (31.0) |
| QUKE basal area ($m^2ha^{-1}$) | 4.3 (0.8) | 1.6 (10.6) | 0.8 (0.4) | 2.4 (0.8) | 0 | 4.3 (1.2) |

Overstory cover of both the moderate and high-severity grids decreased between 2008 and 2012 largely because of dead needle and oak leaf fall (Table 3). Small-diameter dead twigs and branches dropped over time which explains the increase in CWD in the ≤ 10 cm diameter class. Accumulation of CWD >11 cm diameter did not change during the study (Table 3) and, despite high stem mortality in the burn areas, few fire-killed trees had fallen five years post-fire.

Not surprisingly, litter increased and bare ground decreased in the post-fire years (Table 3). Live shrub and black oak resprout cover increased over time in the burn grids. Oak resprout cover increased rapidly in the early post-fire years while shrub cover showed the highest increase in years four and five. The increase in shrub cover was most apparent on the high-intensity grids where the increase averaged 26.2% compared to 11.1% on moderate-severity grids (Table 3). For example, in 2008 mountain whitethorn seedlings were 1-cm high but by 2012 they averaged of 28.3 (SD ± 2.0) cm in the high-severity grids.

*Trapping Results*

Between 2008 and 2012, 5,280 trap nights yielded a total of 469 individuals of eight rodent species. The two most common species were pinyon mice (193 individuals) and deer mice (161 individuals). We captured 81 chipmunks and, based on animal weights, we

Table 3. Changes in microhabitat variables between 2008 and 2012 in each burn type. Values are means ± 1 SD.

| Variable | Unburned | | Moderate severity | | High severity | |
|---|---|---|---|---|---|---|
| | 2008 | 2012 | 2008 | 2012 | 2008 | 2012 |
| Overstory | 51.3 (33.6) | 55.6 (30.6) | 56.4 (31.9) | 30.0 (24.5) | 39.1 (35.5) | 18.0 (22.4) |
| Shrub | 11.7 (19.1) | 13.7 (22.1) | 2.3 (6.4) | 13.4 (19.9) | 8.8 (12.5) | 35.0 (32.1) |
| Black oak resprouts | 0.1 (0.5) | 0.2 (0.5) | 0.4 (0.9) | 1.3 (5.5) | 2.3 (7.0) | 5.6 (15.9) |
| Litter | 59.3 (26.4) | 55.3 (29.4) | 36.6 (20.6) | 47.3 (26.2) | 12.2 (16.6) | 17.5 (24.1) |
| Bare ground | 14.2 (15.8) | 17.2 (13.8) | 47.6 (21.7) | 27.4 (24.4) | 59.3 (29.4) | 34.0 (28.7) |
| < 10 cm CWD | 0.8 (0.9) | 0.6 (0.6) | 0.8 (0.8) | 1.5 (2.9) | 1.0 (2.4) | 2.4 (4.4) |
| 11–30 cm CWD | 0.6 (2.7) | 0.8 (2.2) | 0.4 (0.7) | 0.1 (0.5) | 0.2 (0.5) | 0.2 (0.5) |
| >30 cm CWD | 0.8 (2.5) | 1.0 (2.3) | 0.1 (0.4) | 0.1 (0.1) | 0.1 (0.5) | 0.2 (1.2) |
| Total CWD | 2.2 (4.3) | 2.4 (6.1) | 1.3 (1.3) | 1.7 (3.0 | 1.3 (2.7) | 2.7 (4.8) |
| Rock outcrops | 5.7 (14.6) | – | 4.8 (17.1) | | 9.7 (21.0) | – |
| Diffuse rock | 6.6 (15.3) | – | 2.2 (4.5) | | 2.3 (4.9) | – |
| Total rock | 12.3 (21.6) | – | 7.0 (17.5) | | 12.0 (21.0) | – |

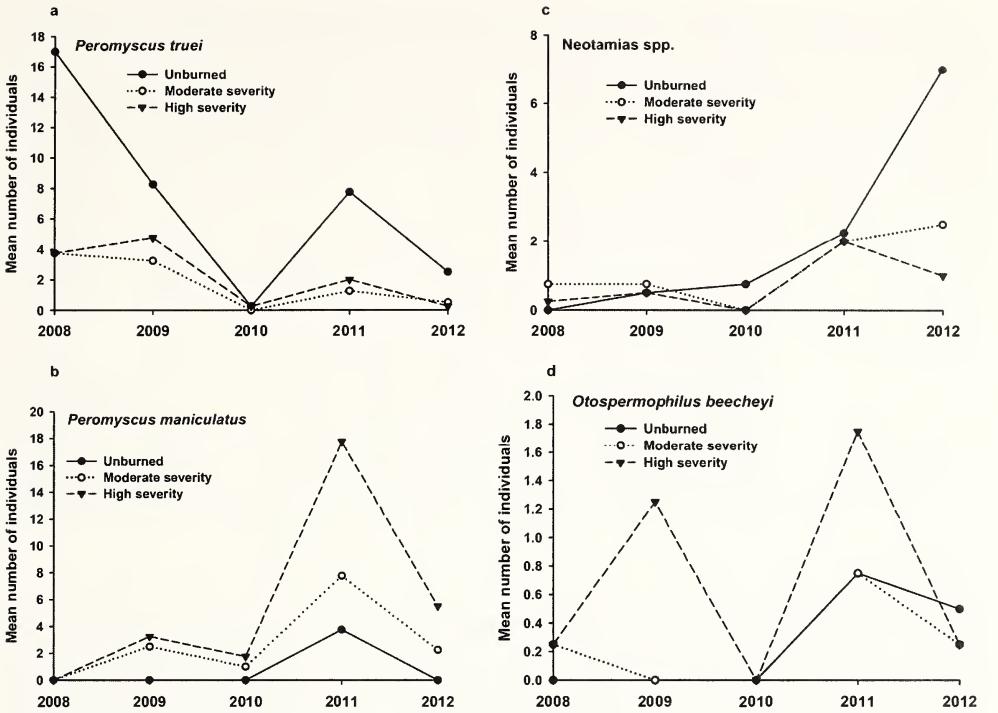


Fig. 1a. Mean number of pinyon mice (*Peromyscus truei*) in the three burn types: unburned, moderate severity and high severity. 1b. Mean number of deer mice (*Peromyscus maniculatus*) in the three burn types: unburned, moderate severity and high severity. 1c. Mean number of chipmunks (*Neotamias merriami* and *N. obscurus*) in the three burn types: unburned, moderate severity and high severity. 1d. Mean number of California ground squirrels (*Otospermophilus beecheyi*) in the three burn types: unburned, moderate severity and high severity.

captured 24 California ground squirrels. In addition, we captured three big-eared woodrats (*Neotoma macrotis*), four golden-mantled ground squirrels, one Pacific kangaroo rat (*Dipodomys agilis*) and one brush mouse (*Peromyscus boylii*).

### *Pinyon Mice*

Pinyon mice were consistently most abundant in unburned forests throughout the study (Fig. 1a), except in 2010 when few mice were captured in any burn type. The NBR analysis showed pinyon mice numbers were significantly related to both burn type and years-after-fire (Table 4). In pairwise comparisons, unburned vs. moderate severity was significant ($p < 0.001$) as was unburned vs. high severity ($p = 0.001$). On the other hand, high and moderate severity types were not significantly different ($p = 0.54$).

### *Deer Mice*

Deer mice were higher in both moderate and high-severity grids than in unburned grids (Fig. 1b). Deer mice numbers were significantly related to both burn type and years-after-fire (Table 4). In pairwise comparisons, unburned vs. moderate severity was significant ($p = 0.01$) as was unburned vs. high severity ($p < 0.001$). High and moderate severity types were not significant ($p = 0.11$). Deer mice first appeared in the burned grids in 2009. They were present in unburned grids in just one year (2011) (Fig 1b).

Table 4. Significant covariates in the negative binomial regressions of the numbers of pinyon mice, deer mice, chipmunks and California ground squirrels. Significant p-values are highlighted in bold. SE is one standard error of the regression coefficient.

| Species | Covariate | Regression coefficient | SE | z-statistic | p-value |
|---|---|---|---|---|---|
| Pinyon mouse | Intercept | 3.60 | 0.56 | 6.41 | **< 0.001** |
| | Burn type | −0.65 | 0.21 | −3.09 | **0.002** |
| | Years-after-fire | −0.45 | 0.12 | −3.70 | **< 0.001** |
| Deer mouse | Intercept | −3.67 | 0.50 | −4.57 | **< 0.001** |
| | Burn type | 0.98 | 0.25 | 3.96 | **< 0.001** |
| | Years-after-fire | 0.73 | 0.15 | 4.99 | **< 0.001** |
| Chipmunks | Intercept | −1.26 | 0.50 | −2.50 | **0.01** |
| | Burn type | −0.52 | 0.15 | −3.59 | **< 0.001** |
| | Years-after-fire | 0.69 | 0.10 | 6.74 | **< 0.001** |
| California ground squirrel | Intercept | −3.50 | 1.17 | −2.99 | **0.003** |
| | Burn type | 0.66 | 0.37 | 1.76 | 0.08 |
| | Years-after-fire | 0.35 | 0.21 | 1.64 | 0.10 |

### *Chipmunks*

The number of chipmunks increased steadily in the unburned forest over the five years (Fig. 1c). The NBR analysis showed chipmunk numbers were significantly related to both burn type and years-after-fire (Table 4). In pairwise comparisons of the burn types, unburned vs. moderate severity was significant ($p = 0.01$) as was unburned vs. high severity ($p < 0.001$). High severity and moderate severity types were not significantly different ($p = 0.15$). In the first four years post-fire, chipmunk numbers were relatively evenly distributed among the three burn types but in 2012 numbers in the unburned forest exceeded the moderate and high-severity forests by three and seven times, respectively (Fig. 1c).

### *California Ground Squirrels*

Ground squirrel numbers were erratic in all three burn types over the course of the study (Fig. 1d). Ground squirrel numbers were not significantly related to either burn type or years-after-fire (Table 4).

### *Ordination Analysis*

In the CCA of the three burn types pooled for all five years, significant variables were: years-after-fire ($p = 0.002$), unburned ($p = 0.002$), high severity ($p = 0.004$), litter cover ($p = 0.006$), and bare ground ($p = 0.04$) (Table 5). A Monte Carlo permutation test showed the first canonical axis was significantly correlated with species distribution patterns ($p = 0.002$). The first CCA axis was most highly correlated with years-after-fire, and explained 18.7% of the variance in the species data with a species-environment correlation of 0.715. After this variable, the highest inter-set correlation coefficients for CCA 1 are unburned and high-severity burn types. Deer mouse is located on the left side of the biplot (Fig. 2) because it increased in abundance over time on the high-severity grids (Fig. 1b). California ground squirrel is associated with bare ground in the high-severity burns. In contrast, pinyon mice and chipmunks occupy the unburned (undisturbed) end of the gradient where litter cover was high (Fig. 2).

Table 5. Summary of the canonical correspondence analysis for the combined grids (N = 60) of the unburned, moderate-severity and high-severity forests for the five years of the study. Values are given for the first three axes of the CCA. Presented for each axis are eigenvalues, percentage of the variance explained, species-environment correlations and the inter-set correlation coefficients for variables that were significant ($p < 0.05$) in forward selection.

| Axis | 1 | 2 | 3 |
|---|---|---|---|
| Eigenvalues | 0.459 | 0.105 | 0.039 |
| Cumulative percentage variance of species data | 18.7 | 4.2 | 1.6 |
| Species-environment correlations | 0.715 | 0.351 | 0.234 |
| | Inter-set correlation coefficients | | |
| | Axis 1 | Axis 2 | Axis 3 |
| Years-after-fire | −0.599 | −0.164 | −0.016 |
| Unburned | 0.394 | −0.236 | 0.024 |
| High severity | −0.260 | 0.216 | 0.059 |
| Litter | 0.185 | −0.119 | 0.143 |
| Bare ground | −0.158 | 0.042 | −0.034 |

Years-after-fire was the only significant variable in the analysis of the unburned grids (no Figure presented). CCA Axis 1 (eigenvalue 0.396) explained 15.1% of the total variation in the small mammal data and had a species-environment correlation of 0.664. A Monte Carlo permutation test showed the first canonical axis was significantly correlated to species distribution patterns ($p = 0.002$). This axis reflects the general decrease in captures of pinyon mice (Fig. 1a) and an increase in chipmunks in the five years (Fig. 1c).

In the CCA of the combined moderate- and high-severity grids four variables were significant: years-after-fire ($p = 0.002$), rock outcrop cover ($p = 0.01$), litter cover ($p = 0.004$), and the combined cover of live shrubs and resprouting black oaks ($p = 0.02$)

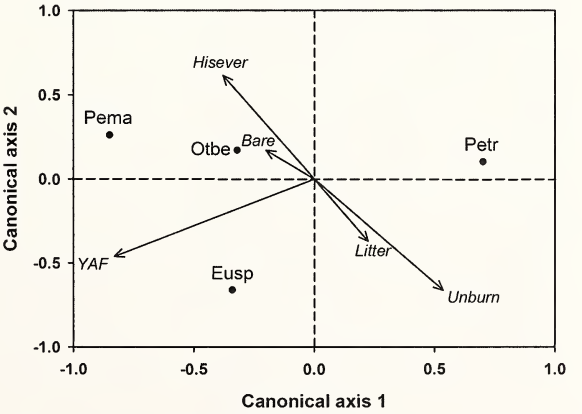


Fig. 2. Biplot of the canonical correspondence analysis of small mammal captures and environmental variables for the grids in the unburned forest and the moderate and high-severity burns. Arrow length indicates the strength of correlation between the variables and the canonical axes. *YAF* is years-after-fire, *Bare* is bare ground cover, *Litter* is litter cover, *Hisever* is high-severity burn grids, *Unburn* is unburned grids. Species acronyms are: Pema = *Peromyscus maniculatus*, Petr = *Peromyscus truei*, Nesp = *Neotamias merriami* and *N. obscurus* combined, and Otbe = *Otospermophilus beecheyi*.

Table 6. Summary of the canonical correspondence analysis for the combined grids (N = 40) of the moderate-severity and high-severity forests for the five years of the study. Values are given for the first three axes of the CCA. Presented for each axis are eigenvalues, percentage of the variance explained, species-environment correlations and the inter-set correlation coefficients for variables that were significant ($p < 0.05$) in forward selection.

| Axis | 1 | 2 | 3 |
|---|---|---|---|
| Eigenvalues | 0.405 | 0.074 | 0.014 |
| Cumulative percentage variance of species data | 17.0 | 3.1 | 0.6 |
| Species-environment correlations | 0.677 | 0.299 | 0.147 |
| | Inter-set correlation coefficients | | |
| | Axis 1 | Axis 2 | Axis 3 |
| Years-after-fire | −0.677 | 0.021 | −0.006 |
| Rock outcrop | 0.119 | 0.199 | −0.003 |
| Bare ground | 0.134 | −0.140 | −0.119 |
| Oak resprouts and shrubs | −0.132 | 0.213 | 0.002 |

(Table 6). Once again, Axis 1 was best correlated (−0.68) with years-after-fire which explained 17% of the variance in the small mammal data and was significantly correlated to species distribution patterns ($p = 0.002$). The positions of deer mice and pinyon mice on the first axis (Fig. 3) reflect the general increase in deer mice captures (Fig. 1b) in burned areas and a decrease in pinyon mouse densities in the unburned forests in the years-after-fire (Fig. 1a). Except for years-after-fire, inter-set correlation coefficients for the other four significant variables were low with the highest coefficient of only −0.213 for combined black oak resprout and shrub cover on CCA 2 (Table 6).

The second axis also was significantly correlated to species distribution patterns ($p = 0.01$) and depicts a gradient from relatively high rock outcrop and combined shrub and

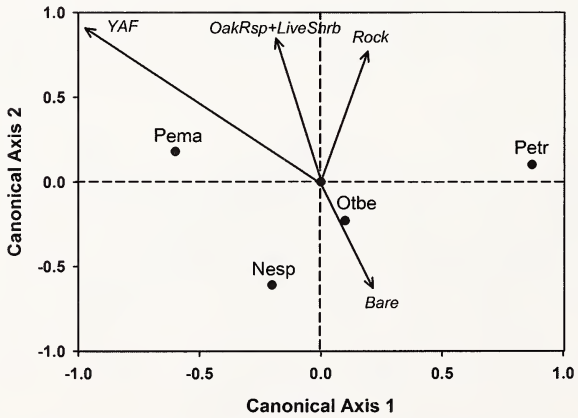


Fig. 3. Biplot of the canonical correspondence analysis of small mammal captures and environmental variables for the grids in the moderate and high-severity burns. Arrow length indicates the strength of correlation between the variables and the canonical axes. *YAF* is years-after-fire, *Rock* is rock outcrop cover, *Bare* is bare ground cover, *OakRsp* is California black oak resprout cover and *LiveShrb* is the cover of living shrubs. Species acronyms are: Pema = *Peromyscus maniculatus*, Petr = *Peromyscus truei*, Nesp = *Neotamias merriami* and *N. obscurus* combined, and Otbe = *Otospermophilus beecheyi*.

oak resprout cover (upper quadrants) to the relative absence of cover in the open represented by bare ground (bottom right quadrant) (Fig. 3). In the burned forests, deer mice show an affinity for the combined cover of oak resprouts and shrubs while pinyon mice favor rock outcrops. Chipmunks and California ground squirrels were captured frequently in the open, away from cover (Fig. 3).

## Discussion

Three of the four species in this study showed a response to fire. Pinyon mice declined on the burn areas compared to the unburned forests (Fig 1a) while deer mice increased in the burn areas (Fig. 1b). Chipmunks were equally common in all three burn types for the first four years but increased markedly on unburned grids in the fifth year (Fig. 1c). Statistically, chipmunks responded negatively to fire. California ground squirrels did not appear to be affected by the fire (Fig. 1d). While three species showed a significant change in numbers compared to the unburned grids, comparisons between moderate and high severity burns were not significant for any of the species. Thus, differences in fire severity had no apparent effect on species responses.

This is the first post-fire study of pinyon mice in conifer forests. Pinyon mice were consistently most abundant in unburned forests and decreased, but did not disappear, in burned forests (Fig. 1a). There are three post-fire studies on pinyon mice: two in chaparral (Lawrence, 1966; Borchert and Borchert, 2013) and one in coast live oak (*Quercus agrifolia*)-blue oak (*Q. douglasii*) forests (Tietje et al., 2008). In oak forests pinyon mouse abundance was higher in the burned compared to the unburned area but only in the first fall after a low-intensity prescribed burn (Tietje et al., 2008). In their study pinyon mice became more abundant in the burn areas three and four years post-fire which is the opposite of our results showing pinyon mouse numbers were higher in unburned compared to burned areas four and five years post-fire (Fig. 1a).

In the unburned grids, where densities were highest, pinyon mice were microhabitat generalists, even though rock outcrops were common on all the unburned grids (Table 2). In the burned grids, in contrast, pinyon mice favored rock outcrops especially in the first two years post-fire (Fig. 3). Pinyon mice in desert habitats have shown a consistent preference for rocky habitats (cliffs and rock outcrops) (Geluso, 1971; Hoffmeister, 1981; Llewllyn and Jenkins, 1987; Pearson and Theimer, 2004). Tietje et al. (2008) found pinyon mice were more abundant in both burned and unburned plots where shrub density was highest. The decline in pinyon mice densities in our study also was associated with the loss of understory shrub cover but, unlike Tietje et al. (2008), we did not observe an increase in densities as understory cover improved.

The lower numbers of pinyon mice in the burned forests may have been due to the loss of shrub and oak cover and coarse woody debris (Table 3) which, in the early post-fire years, may have compelled them to seek refuge from predation in rock outcrops. Moreover, pinyon mice are more arboreal than deer mice (Holbrook, 1978; Ribble and Samson, 1987) so the loss of shrub and oak canopies in the burn areas may have eliminated a particularly important food resource (acorns and seeds).

Deer mice in this study followed a disturbance gradient by increasing in abundance from unburned forests to high-severity burns (Fig. 1b). Deer mice are habitat generalists, although they tend to favor open, xeric habitats (Zwolak, 2009). Despite being habitat generalists, deer mice are disturbance specialists (Keftig and Ahlgren, 1974; Martell, 1984; Kyle and Block, 2000; Zwolak and Foresman 2007; Zwolak 2009; Fontaine and Kennedy, 2012 but see Roberts et. al. 2008). More specifically, they increase in

abundance as disturbance intensity increases (Zwolak, 2009). Our results add to the many studies that consistently show deer mice increase after high severity fires.

Although numerous studies have focused on changes in densities of deer mice in response to fire, few have addressed their microhabitat affinities in burned areas. Most microhabitat studies of deer mice have focused on unburned conifer forests (summarized in Converse et al., 2006a). There were too few captures of deer mice in unburned forests to describe microhabitat preferences in this study. In the burned forests, however, deer mice were frequently captured under or near shrub and oak resprout cover (Fig 3). Kyle and Block (2000) also noted a positive relationship between deer mice densities and increasing forb and shrub cover. In burn areas Zwolak et al. (2012) found a positive relationship between deer mice numbers and open areas and coarse woody debris but not shrub cover.

Chipmunk numbers differed significantly among burn types and years. In our study they increased steadily in the unburned grids over the five years (Fig. 1c). Other studies have shown that the responses of chipmunks to prescribed fire and wildfire in conifer forests are highly variable. After prescribed burns, which most closely resemble the moderate-severity burn in this study, chipmunks responded negatively (Converse et al., 2006c; Maguire et al., 2008) or showed no response (Monroe and Converse, 2006; Meyer et al., 2007; Amacher et al., 2008). After wildfire, chipmunks declined in burned compared to unburned areas (Martell, 1984; Kyle and Block, 2000; Roberts et al., 2008) or showed no change (Monroe et al., 2004; Converse et al., 2006b; Zwolak and Foresman, 2007; Converse et al., 2006a). The increase in chipmunks in the unburned forest in our study suggests it may become more prevalent in this type but a longer study is needed to verify this trend.

California ground squirrels numbers were not significantly related to burn type (Table 4). In Yosemite National Park the capture rate for California ground squirrels decreased with increasing fire severity and, unlike this study, squirrels were not captured in high-severity burns (Roberts et al., 2008). In another study of Sierran mixed conifer forests Amacher et al. (2008) failed to find a significant difference in the abundance of California ground squirrels among the following treatments: unburned, low-intensity prescribed burn, mechanical thinning treatments and thinning plus fire.

Results of the ordinations were similar in that relatively little variation in the small mammal distributions were explained by stand structure or microhabitat characteristics. Microhabitat affinities of small mammals that developed in the burned areas were modest at best (Table 6). Even so, a comparison of burned and unburned forests showed that the microhabitats small mammals occupied changed after fire. In unburned forests none of the stand structure or microhabitat variables explained the distributions of the four common species. In contrast, in the burned forests small mammals showed greater microhabitat segregation—the crecitids favored cover elements while chipmunks and California ground squirrels were active in the open (Fig. 3), presumably where herbaceous food resources were more abundant.

## Conclusions

High-severity fire in conifer forests has traditionally been viewed as both unnatural and undesirable by land management agencies (Bond et al., 2012). However, as studies accumulate on the response of the fauna to moderate and high-severity fire, it is becoming apparent that early stages of forest succession play a vital role in landscape recovery (Swanson et al. 2011). Many species benefit from this early stage and others are

highly dependent on it (Bond et al., 2012; Hanson et al., 2013; Odion and Hanson, 2013). Still, the number of post-fire studies on different vertebrate groups is uneven at best. Fontaine and Kennedy (2012) carried out a meta-analysis of the response of birds and small mammals to low/moderate and high-severity fire. There were 52 studies of birds but only twelve studies of small mammals, of which only two were in high-severity burns. Moreover, none of the small mammal studies lasted longer than four years. Bats, medium-to-large mammals, amphibians and reptiles studies summed to five.

Research on the effects of fire on vertebrate groups in southern California conifer forests lags well behind what is known about vegetation responses. If high-severity fires increase in southern California conifer forests as the climate becomes drier, it is imperative that greater attention be given to the post-fire responses of the fauna.

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# *Psoroptes* Mites and Mule Deer (*Odocoileus hemionus*): Additional Notes from the San Bernardino Mountains, California

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Psoroptic scabies is caused by a mite (*Psoroptes* sp., Asghar et al., 2011; but, see Zahler et al. 2000) and affects bighorn sheep (*Ovis canadensis*) and cattle in the western United States (Singer et al. 1997). Similar to other diseases shared by native and domestic animals, psoroptic scabies has implications for the animal production industry and the health and conservation of wild ungulates (Roug et al. 2012). *Psoroptes* mites previously have been detected on mule deer (*Odocoileus hemionus*) sympatric with a population of desert bighorn sheep in New Mexico (Lange et al. 1980; Hoban 1990; Logan and Sweanor 2001) that was impacted substantially by that ectoparasite (Boyce and Brown 1991). Mite infestations among desert bighorn sheep in California are widespread and commonplace (Mazet et al. 1992; Clark et al. 1993), yet do not appear to result in severe clinical disease (Mazet et al. 1992).

Several of the populations of bighorn sheep examined by other investigators (Mazet et al. 1992; Clark et al. 1993) were sympatric with mule deer, as was the situation in the San Bernardino Mountains, California (Schaefer et al. 2000). Singer et al. (1997) investigated the prevalence of *Psoroptes* infestation among those species and domestic cattle in the southeastern part of that mountain range. Mule deer and bighorn sheep also were sympatric on the north-facing slope of the San Bernardino Mountains (Cushenbury Canyon, Bleich et al. 2009; Abella et al. 2011), and often share chaparral-dominated habitats in other parts of the transverse ranges and in the peninsular ranges of California (Bleich and Holl 1982). Psoroptic scabies was present in bighorn sheep captured in the San Bernardino Mountains at Cushenbury Canyon (Clark et al. 1988) and near Mt. San Gorgonio (Singer et al. 1997).

Singer et al. (1997) reported an absence of *Psoroptes* infestation among 15 mule deer captured near Mt. San Gorgonio. The small number of deer examined, however, limits the ability to make a conclusion based on negative detection of a pathogen or other anomaly (Hanley and Lippman-Hand 1983; Dougherty and McInerney 2009; Ho 2009). Singer et al. (1997) recognized a need to replicate results and recommended further investigation of pathogen-sharing among sympatric populations of mule deer and bighorn sheep. Therefore, we sampled additional mule deer from the San Bernardino Mountains to further explore the question of whether *Psoroptes* mites infest mule deer

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Table 1. Sample size and associated level of confidence that the prevalence ($P$) of *Psoroptes* mites was ≤ 10% in two proximate populations of mule deer, each numbering an estimated 200 individuals and sympatric with bighorn sheep in the San Bernardino Mountains, San Bernardino County, California, 1991–2004.

| Source | Date | Approximate study centroid of area[a] | $N$ | Level of confidence $P^b \leq 0.10$ |
|---|---|---|---|---|
| Singer et al. (1997) | 1991–94 | 34°04′N, 116°39′W | 15 | 81% |
| This study | 2002 | 34°21′N, 116°55′W | 16 | 83% |
| This study | 2004 | 34°21′N, 116°55′W | 18 | 86% |

[a] Latitude and longitude, WGS84 datum.

[b] Probability of exposure estimated according to the method of Wehausen (1987).

that are sympatric with bighorn sheep in that range, as originally posited by Singer et al. (1997).

We captured mule deer in the vicinity of Cushenbury Canyon during 2002 and 2004. We used a net-gun fired from a helicopter (Jessup et al. 1988); deer were physically restrained, and some individuals were transported by helicopter to a central base for processing (Monteith et al. 2011; Monteith et al. 2013), but those caught >10 km from that base were processed in the field. Each individual received prophylactic injections of penicillin (Sterile Penicillin Procaine G; Aspen Veterinary Resources, Liberty, MO, USA), Vitamin E (Vital-E®; Schering-Plough Animal Health Corporation, Summit, NJ, USA), and Vitamin E and Selenium (MU-SE®; Schering-Plough Animal Health Corporation, Summit, NJ, USA), and each was fitted with a VHF telemetry collar prior to release. Capture and handling procedures followed protocols developed by the California Department of Fish and Wildlife (CDFW) (Jessup et al. 1986) and were consistent with guidelines for acceptable field methods adopted by the American Society of Mammalogists (Animal Care and Use Committee 1998).

We conducted a thorough physical examination of each deer in an effort to detect clinical evidence of mite infestation, paying careful attention to the ears as described by Welsh and Bunch (1983). We searched both ears of each individual for evidence of dermatitis in the form of exfoliated epidermis, crusted serous exudate, or blockage of the meatus with hard, waxy material that would be consistent with clinical evidence of *Psoroptes* infestation (Welsh and Bunch 1983). We also collected deep ear swabs (Singer et al. 1997), which were examined microscopically for presence of *Psoroptes* mites. None of the mule deer captured in 2002 ($n$ = 16) or 2004 ($n$ = 18) revealed clinical evidence of *Psoroptes* infestation. Further, deep ear swabs collected from mule deer captured during September 2002 and later examined microscopically ($n$ = 5) were negative for mites (K. R. Jones, CDFW, *in litt*, 14 March 2013).

It will be possible to establish an unambiguous absence of *Psoroptes* infestation in mule deer in the San Bernardino Mountains only if every individual can be sampled (Wehausen 1987). Nevertheless, using the method developed by Wehausen (1987), it can be stated with a high degree of confidence ($\bar{x}$ = 83.33% ± 4.023 [95% CI]; Table 1) that the infestation rate during each sampling period was ≤10%. Moreover, assuming that the infestation rates in each of the 3 sampling periods were independent, it is highly likely ($P$ = 0.9945; $1-[\{1-0.81\}\times\{1-0.83\}\times\{1-0.87\}]$) that the infestation rate among the populations of mule deer examined was ≤10%.

Our failure to detect clinical evidence of psoroptic scabies or the presence of *Psoroptes* mites is consistent with the results of Singer et al. (1997), who detected no evidence of *Psoroptes* infestation among the mule deer they examined. Given the similarity of the level of confidence for each sampling effort, it is entirely plausible that no deer in the geographic areas investigated by us or Singer et al. (1997) were infested with mites. Our results provide additional evidence, as emphasized by Singer et al. (1997), that mule deer are an unlikely source of *Psoroptes* mites that infest bighorn sheep inhabiting the San Bernardino Mountains. Nevertheless, we cannot rule out other species of wildlife as potential sources of infestation of bighorn sheep by *Psoroptes* mites.

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# Natural Egg Sac Clutch Size of the Brown Widow Spider, *Latrodectus geometricus* (Araneae: Theridiidae) in Southern California

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The brown widow spider, *Latrodectus geometricus* C. L. Koch, 1841, is a non-native arachnid that became established in peninsular Florida in the 1930s (Pearson 1936). In the first decade of the 21st century, it rapidly spread through the southeastern United States and southern California (Brown et al. 2008; Vincent et al. 2008; Vetter et al. 2012a) and has become a ubiquitous urban pest species in the Los Angeles Basin and San Diego area (Vetter et al. 2012b). One possible reason for its success lies in its fecundity, as it can produce an egg sac every four days during its earliest ovipositions and averages 22 egg sacs in a lifetime (Bouillon and Lekie 1961).

We were interested in documenting the seasonal field egg production of brown widows from June to October to determine whether there is a specific peak and subsequent drop-off in productivity or whether it is fairly consistent throughout the summer season. This provided basic biology information that benefitted research involving insecticide bioassays on brown widow egg sacs (Vetter et al, in prep); knowing the phenology of seasonal clutch size helped determine whether lab-produced egg sacs would be temporally comparable with natural oviposition and, hence, whether pesticides tested on egg sacs would have real world relevance.

To determine monthly egg clutch size, brown widow egg sacs were collected during the day from several cities in Orange and Riverside counties, California from June through October 2012. Collections were restricted to urban sites such as around homes, in parks, under playground equipment, etc. as documented favored habitats for this spider (Vetter et al. 2012b). We attempted to collect egg sacs primarily from sites that were occupied by female brown widows as this presumedly increased the chances of collecting sacs with freshly laid eggs. The study was terminated at the end of October because temperatures cool considerably in November in southern California.

We did not collect egg sacs for the first seven days of any month in order to more accurately assign sacs with eggs to the correct month of oviposition. At 29°C, brown widow eggs hatch in 9 days. Considering that daily high temperatures in many of our collection locales are typically 35 to 40°C, we felt that this was an acceptable estimate to separate clutch size into monthly cohorts. We also received some sacs in the mail from citizen scientists who participated in previous brown widow studies (Vetter et al. 2012a,b); again, no data from sacs collected and received during the first week of the month were used.

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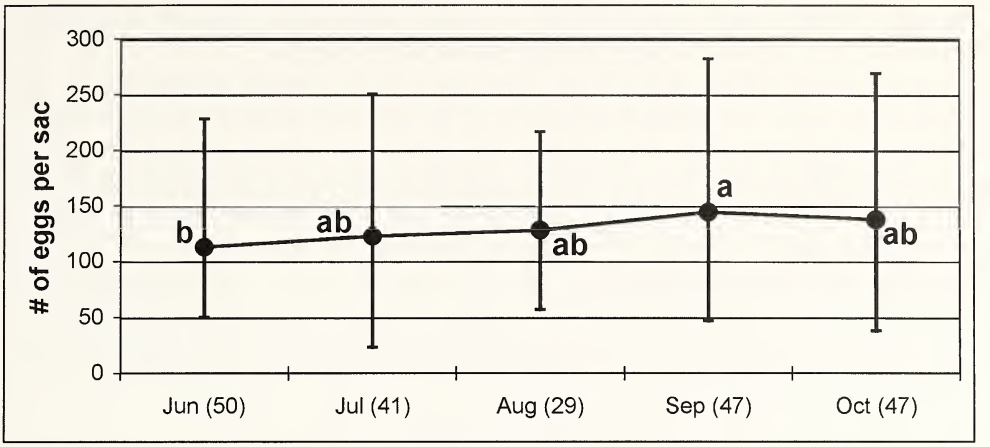


Fig. 1. Seasonal egg clutch size of field-collected brown widow spider egg sacs from June to October 2012 in southern California. Represented here is the minimum, maximum and mean for each month. The number in parentheses following the month is the sample size. Means sharing no letters in common are significantly different.

Egg sacs were dissected over petri dishes with fine forceps while viewed under a microscope. Eggs were counted soon after collecting or the sac was placed in the freezer to stop development, whereupon eggs were counted at a more convenient time. Freezing did not affect consistency of the contents; i.e., the eggs retained their round shape and did not collapse. We did not count any development stage past eggs as this would make it difficult to accurately assign the date of oviposition to a specific month. The sac was ripped open and its contents poured into a petri dish. We checked eggs to verify if they were viable (i.e., spherical and pearlescent rather than wrinkled or collapsed and discolored). Eggs were counted and the sac was checked for residual eggs stuck to the silk.

Numbers of eggs per sac by month were analyzed with ANOVA with separation of means determined by a Tukey's test. Of the many hundreds of egg sacs we dissected, 214 field-collected sacs contained an average of 129.0 ± 51.0 eggs. The monthly means were not statistically equal (ANOVA: $F = 2.87$, $df = 4$, $P = 0.024$). The only statistically significant monthly difference occurred between June with a low mean of 112.9 ± 43.4 and September with a high mean of 144.1 ± 57.5 (Fig. 1).

In this study, brown widow egg production was fairly steady for a 5-month period bracketing the summer with a significant monthly difference of brown widow egg sac clutch size between June and September (Fig. 1). Baerg (1954) reported that 11 brown widow spider egg sacs collected in Haiti when the rainy season was well underway produced an average of 88 eggs per sac (range = 19 to 138). In contrast, southern California brown widows produced about 50% more eggs in 2011 (mean = 143.7 ± 61.6, range = 57 to 286, N = 30) (Vetter et al. 2012a) and in 2012 (mean = 129.0 ± 51.0, range = 23 to 282, N = 214) (this study) although Baerg's average for a small sample size is not much different than our total for June alone (mean = 112.9). Similar to southern California, Triana et al. (2012) recorded 141.9 ± 62.4 eggs for 47 brown widow egg sacs in Costa Rica. Seasonal variation in clutch size is probably influenced by many factors including prey availability and female senescence. However, some of these factors may be ameliorated in urban southern California as the brown widow is a nuisance species and is

thriving around homes with artificially controlled landscaping probably providing a constant source of food for them throughout the warm months.

For the brown widows in our study, there was a fairly constant monthly rate of egg productivity unlike the bimodal periodicity of the uloborid spider *Octonoba octonarius* (Muma) (Peaslee and Peck 1983) or the well-known, late-summer spike of oviposition exhibited by orb weavers. Nor was there a seasonal cessation over the period we collected such as in the confamilial *Theridion melanurum* Hahn, which is an early season layer, ceasing egg production by the end of June in California's San Joaquin Valley (Vetter and Carroll 2013). The information provided by this study signified that we could conduct pesticide testing experiments from June through October and feel confident that we were procuring egg sacs from laboratory-maintained female brown widows during a period when they were normally producing sacs in nature.

## Acknowledgments

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# FRIDAY ABSTRACTS IN PROGRAM ORDER

## 1 WHAT PARASITES CAN TELL US ABOUT WETLANDS - A STUDY OF FISH AND MACROINVERTEBRATE PARASITES IN AN URBAN SOUTHERN CALIFORNIA MARINE WETLAND COMPLEX

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Transmission of parasites is dependent on the development of intimate relationships between parasites and host food webs and behavior. The presence of parasites in a host can therefore provide ecological information on the host and surrounding ecosystem. In 2012, a marine ecosystem characterization study was conducted in the Anaheim Bay/Huntington Harbor wetland complex, which included an analysis of fish and macro-invertebrate parasites. Differing uses and stewardship levels of this important coastal resource offers a unique opportunity to look at parasites between a deep-water port, a natural tidal marsh and restored wetlands habitats, all within a small geographic area. Parasites of seven species of fish and five species of macro-invertebrates were enumerated at ten localities. Fifty species/morphotypes of parasites were identified including at least five species that may be new to science. Univariate and multivariate analyses of parasite abundance allowed discrimination of wetland microhabitats and information on host ecology and interrelationship of intermediate and final hosts. Deep harbor waters, intact natural wetlands and tidal basins constructed as mitigation, contain unique parasite assemblages that can be related to differing food webs and restricted host movement/distributions.

## 2 THE PARASITIC COMPONENT OF KELP FOREST BIODIVERSITY: WHAT CAN THE LITERATURE TELL US?

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The parasitic component of biodiversity has only been quantified in a handful of ecosystems, and in those systems, parasites impact energy flow, food web stability, and connectance. I hypothesized that parasites comprise a large, unquantified component of kelp forest diversity. As a preliminary investigation, I used a published food web of the Santa Barbara Channel kelp forests and conducted systematic database searches to assess potential parasite diversity. The majority of parasite records were for commercially exploited fishes, with sparse data for most fishes and invertebrates. Fishes are the most resolved taxon, with 50 species in the food web. For those 50 hosts, 260 parasites have been reported in the literature. Simply adding these fish parasites would more than double the size of the kelp forest web. Parasite diversity was not evenly distributed among fish, with 4 fish species accounting for 49% of parasite diversity. The number of recorded parasites per host increased with the number of publications for that host, with many understudied hosts. However, the type of study had a greater impact on parasite diversity than the number of studies. Species accumulation curves suggest that a targeted study can capture a large fraction of the true parasite biodiversity, and demonstrate that studies vary greatly in their contribution to the parasite diversity captured.

## 3 INTRASPECIFIC VARIATION IN GROWTH AND REPRODUCTION OF THE MARINE LEECH, HEPTACYCLUS BUTHI

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*Heptacyclus buthi* was harvested from fish hosts in rocky intertidal zones of Sonoma and Marin Counties, California in 2008 (N = 162) and 2010 (N = 51). The size of the leeches was quantified using a method that approximated the sagittal cross-section of each specimen. Size-frequency curves were modeled

to estimate the number of size-class cohorts in each year. If *H. buthi* is an annual species like many of its relatives, the single cohort modeled for in 2010 and the comparable "older" cohort in 2008, both with a broad range of sizes, may represent one component of its reproductive life history. A second, younger, more-numerous, less-variable cohort modeled from the 2008 sample may represent a second reproductive bout during that year that was prevented in the subsequent La Niña period of 2010-11.

## 4 SOCIALITY IN TREMATODE FLATWORMS

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The phenomena of behavioral specialization, polymorphism and caste formation is well known for some organisms, such as social insects and naked mole rats. Recent findings extend such complex sociality to a new phylum- the Platyhelminthes. Trematode flatworms clonally form colonies in their molluscan first intermediate hosts, and some species have a reproductive and a soldier caste. Reproductives are larger and filled with offspring. Soldiers are small, have relatively large pharynxes, and attack and kill unrelated trematodes more readily; soldiers are also more active and disproportionately common in areas of the host where invasions occur. This reproductive division of labor has been documented for five trematode species from different geographic regions and host species, suggesting that a social system with a soldier caste is widespread among trematodes. Here, we examine the nature of sociality for an additional 14 trematodes species that infect the California horn snail, *Cerithidea californica*. Half of these species appear to have a division of labor involving a non-reproductive soldier caste, while the other half provide information on colony structure when soldiers are lacking. Hence, the diverse guild of trematode species infecting the California horn snail provides a valuable tool to address questions regarding the ecology and evolution of sociality, as well as to examine basic processes and mechanisms underlying the development and regulation of trematode caste systems.

## 5 LEVELS OF METALS IN TWO LIFE STAGES OF THE TREMATODE EUHAPLORCHIS CALIFORNIENSIS AND THEIR RESPECTIVE HOSTS, NAMELY THE CALIFORNIA HORN SNAIL AND THE KILLIFISH

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Pollutants can accumulate through the food chain from prey to predator. Less considered is that parasites might absorb pollutants from a host and then transfer them to the next host in the life cycle. We measured metal pollutants in *Euhaplorchis californiensis*, a trematode species whose complex life cycle involves two aquatic hosts, the California horn snail (*Cerithidea californica*) and the California killifish (*Fundulus parvipinnis*). Snails and killifish, were collected from Carpinteria Salt Marsh Reserve (Santa Barbara, CA), a site where we had also mapped contaminants in the sediment. Infected hosts were dissected and host and parasite tissues were analyzed for a suite of metals using the inductively coupled plasma optical emission spectrometry (ICP-OES). In addition to tracing the flow of pollutants among species in an ecosystem, this cross interdisciplinary study can help identify hot spots of chemical contamination in ecological health assessments across host species and environments.

## 6 MAINTAINING THE SCIENTIFIC LEGACY OF SYMBIOTIC COPEPOD RESEARCH

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Copepods are among the most abundant organisms on the planet. Approximately 12,500 species are known, with approximately 100 species being described each year. They are found in aquatic sediments, dominate the plankton, and are parasitic on almost every animal phylum. They are vectors of human

disease, used for disease control, and have a considerable impact on global fisheries. Caligids (sea lice) are responsible for disease-related fish losses that exceed US$480 million worldwide per year. Therefore, it is essential that symbiotic copepod research continue to be an active and expanding field. Researchers can acquire information and techniques from some of the best copepodologists in the world at the International Workshop on Symbiotic Copepoda (IWOSC). The 1st IWOSC was held in December 2010 at Cabrillo Marine Aquarium, U.S.A. and included 30 participants from 13 countries. The 2nd IWOSC was held in July 2013 at University of Limpopo, South Africa and included 39 participants from six countries. These workshops are timely as many experts have recently retired or will be retiring shortly. As such, they are essential for maintaining the scientific legacy of this comparatively smaller, but equally important, group within the global copepod and parasitology communities. Workshop participants learn collection and identification methods, present their research, obtain assistance with identification of their own material, develop scientific collaborations, and can submit a manuscript for publication. The 3rd IWOSC is planned for July 2016 and will be held at James Cook University, Australia.

## 7 SPECIES OF THE CECROPIDAE (CRUSTACEA: COPEPODA) ARE ACTUALLY MEMBERS OF THE PANDARIDAE: EVIDENCE FROM PROSAETES RHINODONTIS

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Robust evidence supporting the validity of the Siphonostomatoida family Cecropidae has always been limited, as species of the Cecropidae and the Pandaridae share many morphological characteristics. We argue that the morphology of *Prosaetes rhinodontis*, a parasitic siphonostomatoid copepod of the whale shark (*Rhincodon typus*), contributes substantially to the blurring of familial limits between the Cecropidae and the Pandaridae, and based on our detailed consideration of this issue we recommend that the Cecropidae be recognized as a junior synonym of the Pandaridae. Within the Pandaridae, representatives of Prosaetes, Cecrops, Luetkenia, Philorthagoriscus, Orthagoriscicola, and Entepherus are considered members of the Dinemoura-group based on their shared possession of a narrow third pedigerous somite and dorsal plates on the fourth pedigerous somite in the adult female and a modified leg 3 terminal endopodal segment in the adult male.

## 8 SOUTHERN CALIFORNIA BIGHT AERIAL SURVEY TO ASSESS PACIFIC SARDINE DISTRIBUTION AND ABUNDANCE

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The Pacific sardine (*Sardinops sagax*) is an important commercial marine fish species in southern California waters, and understanding its distribution and abundance is critical to managing the stock for long-term sustainability. In 2012 and 2013, the California Department of Fish and Wildlife (CDFW), in conjunction with the California Wetfish Producers Association (CWPA), conducted aerial surveys to collect data on sardine distribution and abundance in the southern California Bight (SCB). Direct visual observations were made by an expert observer aboard a CDFW aircraft, with data on fish school species composition, abundance, and estimated tonnage recorded. An on-board data-logging device continuously recorded time, position, altitude and other variables along the flight path. Simultaneously, high-resolution digital photographic images of the ocean surface were taken from the aircraft. Boat – based sampling was also conducted in conjunction with some aerial surveys to verify species identification provided by the aircraft observer as well as to collect biological data. These observations indicated that sardine schools in coastal waters are detected in greater abundance than schools in open water, that school species composition may be influenced by type of coastal habitat, and showed a decrease in point estimates of total SCB sardine tonnage from 2012 to 2013. Additional developments in the application of digital

photogrammetry for estimation of school size and the use of satellite environmental data for habitat analysis will also be described.

## 9 AN OVERVIEW OF THE CALIFORNIA RECREATIONAL FISHERIES SURVEY, A MEANS TO SUSTAINABLY MANAGE CALIFORNIA'S MARINE RECREATIONAL FISHERIES

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The recreational fishery sector accounts for a significant portion of the total take of many marine fish species managed by the state of California. Recreational fisheries are highly dynamic; catch is difficult to track, and fishing effort is challenging to predict. Accurate and timely catch and effort data are necessary to provide management agencies with information essential to effectively protect, enhance, and maintain fishery resources. The California Recreational Fisheries Survey (CRFS), a multi-part survey initiated in 2004, is a collaborative effort between the California Department of Fish and Wildlife (CDFW) and the Pacific States Marine Fisheries Commission (PSMFC) providing marine recreational finfish catch and effort estimates which can be used for management purposes. Field sampling is conducted year-round at over 500 publicly-accessible sites including public launch ramps, piers, docks, jetties, beaches, and onboard commercial passenger fishing vessels. Data on the temporal and geographic distribution of catch and fishing effort are collected and entered by CDFW and estimates are maintained and managed by both CDFW and PSMFC through the Recreational Fisheries Information Network (RecFIN). These data are fundamental for the development of informed management measures, policies, assessments and plans, and are necessary for the sustainable management of many of California's marine resources.

## 10 EVALUATION OF WHITE SHARK (CARCHARODON CARCHARIAS) AS A CANDIDATE SPECIES FOR LISTING UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

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In August 2012, a petition was submitted to the Fish and Game Commission to list the North Eastern Pacific (NEP) population of white shark as threatened or endangered pursuant to the California Endangered Species Act (CESA). The Department of Fish and Wildlife (Department) presented its petition evaluation to the Commission in February 2013 with the determination that there was sufficient scientific information to indicate the species should be made a candidate for listing under CESA. After considering the Department's recommendation, public comment and other available scientific information, the Commission voted to make the NEP population of white shark a candidate species. The Department's full 12-month evaluation of the species status was completed in spring of 2014. After a period of public review, the Department will present these findings to the Commission, which will then make a final determination on the status of the NEP population of white shark. This presentation will address the Department's review of the species, and the CESA process and related permitting process for industry and researchers during the candidacy period.

## 11 MANAGING SUSTAINABLE FISHERIES: THE UTILITY OF A COLLABORATIVE AT-SEA SAMPLING PROGRAM FOR THE CALIFORNIA SPINY LOBSTER FISHERY

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Consistent with the California Marine Life Management Act, a fishery management plan (FMP) is being developed for the state's spiny lobster fishery to help sustain it over the long term. The FMP requires identification of suitable protocols for collecting data, as well as the best available scientific information to

inform management. To address this need for the lobster fishery, our team of scientists, fishery managers and trap fishermen designed and piloted a collaborative at-sea sampling program (CASP). Together we developed protocols that work for the variety of fishing operations and fishing areas. Fishermen were trained in sampling methods, and then collected data while fishing, which were validated at the port. Our collective analyses have identified significant geographic patterns in size distribution, sex ratios and CPUE. We found smaller lobster, less even sex ratios and lower CPUE in the south relative to the central and northern regions and most offshore islands of the Southern California Bight. Data from the south also indicate more sub-legal lobster (i.e., potential future recruits) than the rest of the Bight. The essential fisheries information (EFI) collected by the CASP augments existing management data and will be used to inform the population and fishery dynamics components of the models being considered for the FMP. The demonstrated success of the pilot CASP program for collecting fishery-dependent EFI has generated support for implementing an ongoing CASP program to inform long-term management of the lobster fishery, providing a model for other fisheries.

## 12 CALIFORNIA HALIBUT TRAWL FISHERY: FRESH, LOCAL, SUSTAINABLE

M. McCorkle. Southern California Trawlers Association, Santa Barbara, CA

The California Halibut Trawl Fishery has been variously configured since the first paranzella nets were used off Santa Cruz, California to catch fish in the early 20$^{th}$ century. In 1971, the California Halibut Trawl Grounds were designated from one to three miles offshore, from Point Arguello to Point Mugu. Southern California Trawlers Association members have continuously refined the halibut trawl net to minimize bycatch and any other potential effects on marine ecosystems. A number of recent studies have validated the success of these and other efforts. This presentation briefly outlines the fishery, its boats and grounds, and reviews the results of recent trawl surveys and studies on groundfish and the halibut fishery that demonstrate the sustainability of this fishery. We will continue to improve our techniques for continued sustainability and we would like to re-establish small fishing areas in underfished Central California waters, so that we can continue to provide an enhanced supply of fresh, local California halibut to restaurants, markets and seafood consumers throughout the State.

## 13 OCEAN ACIDIFICATION (OA) AND FISHERIES – HOW FISHERIES WILL (OR SHOULD) RESPOND

B. Steele. PO Box 336, Buellton, CA 93427

The California Current is one of the first places worldwide that will experience surface to seafloor aragonite under-saturation. Under-saturation can inhibit growth and survival in the larval stages of certain shellfish. This large-scale change in the California Current Ecosystem is predicted to occur within the next fifty years. The upwelling of nutrients that feeds our fishery resources also draws high $CO_2$ intermediate waters to the surface along our coast. The processes that deliver the high $CO_2$ waters, the duration of under-saturation, and the timing of events in relation to the period that larvae of sensitive species are in the water column will all need to be incorporated into fisheries management policies. Some important fisheries, oysters for example, have already been affected. Red king crab larvae also have been shown to be sensitive to OA in laboratory studies. Oysters are largely an aquaculture species and the aquaculture industry has made progress in developing procedures to adapt to the changing water conditions. In contrast, wild fisheries will persist or disappear depending upon the sensitivity of individual species to progressively under-saturated seawater. The world's oceans have not experienced this rate of change in more than 30 million years. Fisheries managers are currently unprepared for the upcoming challenges, and the current state of research on OA is only beginning to investigate which species will be affected and how. California fishermen and fisheries managers will witness these changes and what we learn may inform other fishermen worldwide as ocean conditions deteriorate.

## 14 U.S. SUSTAINABLE FISHERIES AND SUSTAINABLE SEAFOOD

M. Helvey. NOAA Fisheries, West Coast Region, Long Beach, CA

NOAA Fisheries is the leading science authority for managing federal marine fisheries of the United States. Under NOAA Fisheries, U.S. fisheries are scientifically monitored and managed and U.S. fishermen follow some of the most restrictive regulations in the world. The U.S. approach for sustainably managing fisheries has become an international model for addressing the challenges facing global ocean fisheries today. NOAA Fisheries is also involved with managing a sustainable aquaculture industry in the United States. To convey that information to the public, NOAA Fisheries developed FishWatch, an easy-to-understand, science-based fact sheet designed to help consumers make smart sustainable seafood choices. FishWatch delivers the most up-to-date information on popular seafood harvested - or farmed - in the United States. It is not a buyer's guide designed to discriminate against one fishery or advocate for another, nor is it an ecolabel or certification. Rather, FishWatch helps the consumer understand the complex science, laws, and management processes actively sustaining our seafood supply. FishWatch provides the facts about the industry, the science, and management behind sustainable U.S. seafood - from the ocean or farm to the consumer's plate.

## 15 FISH ON YOUR DISH: DOES SEAFOOD DIRECT MARKETING HELP SUSTAIN FISHERIES?

**C. Pomeroy**[1], C. Culver[2,3], B. Walker[3], K. Selkoe[3], N. Georgilas[2,3], A. Von Harten[4]. [1]Institute of Marine Sciences, University of California Santa Cruz, CA 95060. [2]California Sea Grant Extension Program, University of California San Diego, CA 92093. [3]Marine Science Institute, University of California, Santa Barbara, CA 93106. [4]Charleston, SC 29407

Interest in alternative (or "direct") approaches to marketing seafood (AMAs) as a mechanism for sustaining fisheries has grown significantly among fishermen and other community members. AMAs are valued for their potential to achieve the often-elusive "triple bottom line" of environmental protection, enhanced economic benefits, and social justice. Through interviews with fishery participants and others knowledgeable of fisheries and seafood marketing on both the US west and east coasts, we are testing hypotheses about the implications of AMAs for fishery participants and communities. Our research has illuminated a diversity of AMAs and factors influencing their use by fishermen. We also have documented practical, economic and social implications of AMAs for fishery participants and communities. AMAs can address some challenges facing fishermen such as stagnant or declining prices, limits on catch, and reduced availability of viable market outlets for their product. However, AMAs – and the fishermen and communities they are purported to benefit – also face a host of challenges, most notably related to infrastructure and institutions to accommodate alternative pathways for delivering seafood more directly to consumers. Whereas some fishermen and communities have found creative ways to address these issues, others continue to struggle with them. Ultimately, the resolution of these issues is key to the success of AMAs and, arguably, the broader economic, social, and ecological sustainability of fisheries.

## 16 FISHING IMPACTS ON THE TROPHIC STRUCTURE OF KELP FOREST FISHES IN SOUTHERN CALIFORNIA

**P.H. House** and L.G. Allen. California State University, Northridge, Department of Biology, 18111 Nordhoff St., Northridge, CA 91330

Fishing pressure has altered community structure of marine habitats worldwide. Multiple studies have shown that overfished ichthyofauna can grow in size, abundance, and reproductive output in no-take Marine Protected Areas (MPAs). This study investigates how size and abundance of targeted predatory fish species influence lower trophic level fishes inside and outside of MPAs in Southern California's kelp forests. A factorial design was used testing the effect of MPA protection on the trophic structure biomass of fish communities by surveying inside and outside of 3 well-established MPAs located at La Jolla, Santa Catalina, and Anacapa Island, CA. At each site, fish were surveyed along 12, 50 × 2 × 2 m underwater SCUBA transects sampling the benthos, open water, and canopy. All conspicuous and transient fish species were counted, sized (using calibrated lasers and video to aid in size estimation bias), and assigned to trophic level. Results show secondary carnivore and herbivore fish biomass decreased significantly outside of the MPA. However, zooplanktivore / primary carnivore biomass significantly increased outside of the protected areas. These results indicate that a decrease in biomass of target fish species may relieve pressure on primary carnivore fishes outside of protected areas. Gaining insight into the trophic role of

predatory species is essential to understanding the ecology of Southern California kelp forests and providing information for fisheries management.

### 17–18 CALIFORNIA'S CHANNEL ISLANDS: AN OVERVIEW

**A.A. Schoenherr**. 414 Bluebird Canyon Drive, Laguna Beach, CA 92651. Ecology Professor, Emeritus, Fullerton College, 321 East Chapman Avenue, Fullerton, CA 92832

The biota of the Channel Islands is the product of a long history of isolation. Mechanisms by which organisms reach islands and what happens to them after they arrived will be reviewed. Passive and active forms of water borne and air borne transport, as well as potential examples of vicariant transport will be discussed. Examples of relictual and autochthonous endemism among island taxa will be described and adaptive radiation among successful island colonizers will be emphasized. Examples of the MacArthur and Wilson (1967) concepts of island biogeography will be discussed where appropriate.

### 19 EXPERIMENTAL REMOVAL OF SARGASSUM HORNERI USING A SUPER SUCKER DEVICE

**B. Meux**, A. Obaza, L. Marks, and B. Chesney. NOAA Fisheries, 501 West Ocean Blvd, Suite 4200, Long Beach, CA 90802

Since the initial discovery of *Sargassum horneri* and *Undaria pinnatifida* in the Port of Los Angeles and Long Beach complex, their range and abundance has dramatically increased throughout the Southern California Bight to include many Channel Islands and coastal embayments. A potential control method is a "super sucker", a suction device capable of simultaneous collection and sorting. Divers manually remove algae and feed it into a suction powered hose that transports algae to the surface for sorting and collection. This device was tested at Catalina Island to determine its efficacy for *Sargassum horneri* control. In September 2013, divers removed 55 kg of S. horneri from a 10 m × 10 m plot at Ship Rock and surveyed results two months later. *S. horneri* decreased in density but increased in size at both plots showing no effect from the removal effort. Very little epifauna was removed or damaged during S. horneri removal by the super sucker, suggesting minimal impacts on non-target species. Future testing of S. horneri control should take place in the winter when a large majority of *S. horneri* reaches its peak biomass and becomes less dense via self-thinning. This will increase the efficiency of removal and may allow sufficient quantities to be removed to yield a sustained reduction in density. In the future, NMFS would like to partner with interested stakeholders to further S. horneri or *U. pinnatifida* control efforts and use this device as a rapid response method for novel invasions throughout Southern California.

### 20 CATALINA ISLAND ECOLOGY, RESTORATION, AND MANAGEMENT INTERNSHIP: BUILDING PARTNERSHIP AMONG AGENCIES WITH DIVERSE INTERESTS

**L.E. Collins** and D.W. Ginsburg. University of Southern California, Environmental Studies Program, Los Angeles, CA, 90089

For three years a summer undergraduate internship program focusing on the natural history and management of Catalina Island has run as a joint effort between the USC Environmental Studies Program (ENST), the Catalina Island Conservancy (CIC), the Santa Catalina Island Company (SCIC), the American Conservation Experience (ACE), and the USC Wrigley Institute for Environmental Studies (WIES). One of the primary goals of this program is to provide an experiential learning opportunity for students enrolled in the USC Environmental Studies Program. Since 2011, four students have worked each summer designing and maintaining the Deer Valley trail adjacent to the WIES campus on Catalina Island. Student activities include the eradication of invasive fennel, monitoring long-term projects to examine the spread of invasive fennel, creating an interactive plant field guide, and overall maintenance of the trail itself. In addition to conducting research projects in the laboratory and field, student-learning outcomes included analyzing data, writing research blogs and reports, and providing outreach activities to members

of the Catalina community. We will present the key aspects that allowed such diverse organizations to come together to the mutually beneficial arrangement that governs this internship program.

## 21 THE PIMU CATALINA ISLAND ARCHAEOLOGY PROJECT

**W.G. Teeter**. Fowler Museum, University of California Los Angeles, Box 951549, Los Angeles, CA, 90095

The Southern Channel Islands off the coast of California were home to the ancestors of the Gabrielino / Tongva for at least 8,000 years. The Pimu Catalina Island Archaeology Project was founded in 2007 as a collaborative undertaking between the Gabrielino/Tongva community, archaeologists, and the Catalina Island Conservancy to synthesize and expand upon the previous research conducted on the island for over fifty years. Many difficulties, including the finding of original documentation, collections, and original site locations, have been daunting, but successful. The field seasons since 2007 have propelled the project forward in amazing ways. This presentation will discuss current research, programs, and overarching goals that help us to better understand the Pimu people and their way of life.

## 22 CHANNEL ISLANDS NATIONAL PARK; STORIES OF ISOLATION, CONNECTIONS, AND CHANGING VALUES

**K.R. Faulkner**. 1901 Spinnaker, Ventura, CA 93001

The five islands in Channel Islands National Park have undergone intense changes during the 34 years since designation of the park. NPS and partners have made major strides in scientific research, ecological monitoring, removal of non-native animals, reestablishment of extirpated species, establishment of no-harvest marine zones, and expanded opportunities for the public to learn about and experience the islands. In many locations, the islands are showing signs of ecological recovery. However, removal of non-native animals has not magically resulted in recovery in all locations. Substantial areas continue to be dominated by bare ground or non-native vegetation. Increasingly, we are looking at impacts that are not under the direct control of island managers. Changing climate, ocean acidification, and removal of marine biomass will have pervasive and challenging impacts on the island ecosystems and biological diversity. Expanded scientific research on and around the islands is needed to improve our stewardship of natural and cultural resources and evaluation of management actions.

## 23 MPA WATCH: CITIZEN SCIENTISTS MONITORING HUMAN COASTAL AND MARINE RESOURCE USE OF MARINE PROTECTED AREAS

**D.R. Murray**, S.A. Sikich and A. Finnila. Heal the Bay, 1444 9th St., Santa Monica, CA 90401

MPA Watch is a citizen science monitoring program that trains volunteers to observe and collect data about human coastal and marine resource use inside and outside California's newly-established marine protected areas (MPAs). Through MPA Watch, trained volunteers categorize observed human uses into a set of activities using standardized protocols, which provides information about how the public uses coastal areas, and can inform management and monitoring of MPAs. MPA Watch program goals include: 1. Determining how effective MPAs are at meeting their goal of enhancing recreational activities, by tracking changes and trends over time; 2. providing contextual information on human use for interpretation of biological and socioeconomic monitoring data; 3. informing MPA management decisions regarding human activity inside MPAs; and 4. building MPA stewardship among program volunteers and the public. Heal the Bay's volunteers collect data from both within and outside MPAs in Malibu and Palos Verdes, allowing for useful comparisons between protected and unprotected area usage. Initial data results from the past three years indicate that fishing activity is decreasing in MPAs along the Los Angeles mainland, although hook-and-line shore fishing regularly occurs within MPAs. Data also indicates that most people are visiting MPAs for non-consumptive activities, with some evidence of increases in wildlife-driven activities. Heal the Bay is actively working with partner groups to build a statewide MPA Watch program, providing an interesting case study about developing a citizen science

program that is applicable to a large geographic region, while allowing for localized participation and customization.

## 24 SUPPORTING CITIZEN SCIENCE IN SOUTHERN CALIFORNIA: CALIFORNIA NATURALIST AND NHM'S NATURE LAB

S. Drill[1] and L. Higgins[2]. [1]University of California Cooperative Extension – Los Angeles County, 700 W. Main St., Alhambra, CA 91805. [2]Natural History Museum of Los Angeles County, 900 Exposition Blvd, Los Angeles, CA 90007

Citizen science, or participatory research, is the collection of scientifically useful information by non-professional volunteer researchers. It encompasses observations of nature, simple experimentation, and crowd-sourced data collection, in which observers help to extract data from sources such as photos of the night sky. We present on two programs that seek to support citizen science in the southern California region. The California Naturalist Program's mission is to promote stewardship of natural resources through education and service by trained, certified, volunteer naturalists. We work to educate non-professional scientists, educators, and conservationists about California's ecosystems. Through experiential education, participants learn to make and record observations, interpret scientific information, and undertake on the ground conservation and restoration. Over the last 11 years, the Natural History Museum of Los Angeles County has been growing a citizen science program that aims to meet the needs of both scientists and urban residents. We reclaimed a former parking lot to build a new outdoor space, the 3.5 acre Nature Gardens, a field site and training ground for urban biodiversity research. Simultaneously, we began expanding our suite of citizen science projects. Located just south of downtown Los Angeles in one of the most park-poor parts of the city, this garden provides Angelenos with space to experience nature, from a first touch with nature—a child holding her first pill bug—to those that are more in-depth—a school group surveying the gardens for the rare nine-spotted ladybug.

## 25 OVERVIEW OF THE CALIFORNIA PHENOLOGY PROJECT AT SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA

C.L. Anderson. National Park Service, Division of Planning, Science and Resource Management, Thousand Oaks, CA, 91320

Phenology is the study of the seasonal timing of biological events such as plant leaf out and flowering, insect emergence and arrival of migratory birds and other animals. The California Phenology Project (CPP) at Santa Monica Mountains National Recreation Area (SAMO) is a citizen science based project operating in partnership with UC Santa Barbara, the USA-National Phenology Network (USA-NPN) as well as with six additional National Parks within California. The project supports scientific research while fulfilling additional National Park Service goals of public engagement and stewardship. Phenological data collection will help scientists discover possible patterns in the timing of phenological events with respect to climate change. Trained National Park Service staff and volunteers use standardized protocols, tools and materials developed by USA-NPN. Since 2011, SAMO volunteers, interns and staff have collected over 180,000 data points on 200 individual plants comprised of six target plant species. Geospatial patterns are emerging such as the difference in the onset date of flowering over an elevation gradient on Sandstone Peak.

## 26 SEEKING OUT STINK BUGS IN SOUTHERN CALIFORNIA: USING CITIZEN SCIENTISTS TO LEARN MORE ABOUT STINK BUG DIVERSITY, BEHAVIOR AND DISTRIBUTION, AND TRACK THE SPREAD OF THE INVASIVE BROWN MARMORATED STINK BUG (*HALYOMORPHA HALYS*)

J.M. Bryant[1] and M.S. Hoddle[2]. [1]Museum Department, City of Riverside, CA, 92501. [2]Center for Invasive Species Research, University of California, Riverside, CA, 92521

The Brown Marmorated Stink Bug (BMSB), while a severe agricultural and homeowner pest on the US east coast, is a relatively new invasive pest in CA and its distribution within the state is not well understood. For this reason, the project partners are launching an effort to recruit citizen science

volunteers to employ smartphone applications and other digital methods for recording and sharing nature observations, in order to document "finds" of stink bugs, in general, in Southern California, and ultimately provide early detection of additional occurrences of BMSB. Most stink bug species are large, easy to photograph, with conspicuous egg masses, and the partners would provide on-line instructions for collecting georeferenced observations as well as simple tools for stink bug identifications and recognition of evidence of parasitism. Once submitted, photo reports would be verified by Museum and UCR Entomology personnel and then databased for analysis. The national BMSB research team will be aided in its planning for deployment and evaluation of a biological control program for this pest. Via on-line sharing tools, volunteer participants would quickly see concrete results of their efforts, acquire a positive picture of native species while heightening alertness to BMSB and other invasive species, and ultimately gain appreciation for the role of naturally-occurring enemies of pests as well as species used in biological control programs.

## 27 SPLATTER SPOTTER: A MOBILE PHONE APPLICATION FOR DOCUMENTING ROAD KILL

S. Anderson. Environmental Science and Resource Management Program, California State University Channel Islands, Camarillo, CA, 93012

Roads and vehicles have profound impacts on the abundance and distribution of vertebrates, with direct mortality (i.e. "road kill") the most obvious such effect. My students and I have been examining road kill across the globe (eastern Turkey, coastal Gulf of Mexico, and here in coastal California) since 2007. The 2012 release of our first citizen science iPhone app both bolstered awareness of road kill and gave anyone interested a chance to contribute to our road kill reporting here and across the world. Individual species killed varies across the planet, but overall mortality is consistently elevated along ecotones or edges. Patterns are clearest within our most intensively-sampled region: in / around Ventura County (>5,200 observed kills during >5,300 individual surveys amounting to >68,000 km driven over the past 7 years). While many factors such as land use, roadside barriers, maximum speed limits, and vehicle traffic correlate with kill rates, gross positioning of the particular road segment within transition zones (wildland-urban interface, etc.) is a key predictor. In the Santa Monica Mountains 4,944 ± 622 (mean ± se) vertebrates are killed annually on major roads, spanning abundant (e.g. 98 coyote kills), common (e.g. 9 owl kills), and rare (e.g. 3 badger kills) species of concern. Kill rate along the range's perimeter exceeds that within its core. We see the same patterns in our Santa Ynez Mountains, Asia's Caucasus Mountains, etc. Road kill has proven to be a powerful way to engage the public in conservations about ecological fragmentation, connectivity, and wildlife corridor issues.

## 28 STUDYING REPTILES AND AMPHIBIANS OF SOUTHERN CALIFORNIA (RASCALS) THROUGH CITIZEN SCIENCE

G.B. Pauly, L.M. Higgins and R.F. Smart. Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007

Most of California resides in the California Floristic Province, one of the Earth's 34 Biodiversity Hotspots. These hotspots define areas with exceptionally high levels of endemism and also exceptionally high threat to this diversity. Much of the threat in the California Floristic Province is due to habitat modification and urbanization as the human population has rapidly increased in the region, especially in southern California. We are using citizen science to obtain detailed contemporary data on distributions of reptiles and amphibians throughout southern California and comparing these records with historical museum records to assess how species are responding to urbanization. Because much of southern California is private property (e.g., back yards), citizen science provides the only reasonable avenue for acquiring large amounts of data from places with restricted access. The Reptiles and Amphibians of Southern California (RASCals) project also improve s detection of non-native species. To date the Museum's citizen science efforts have yielded numerous noteworthy observations including three new county records and one new state record of invasive geckos. In the future, this rapidly growing database will provide information relevant to the conservation and management of local wildlife as well as inform future urban planning that maximizes native biodiversity.

## 29 TOPANGA CREEK STREAM TEAM VOLUNTEER PROGRAMS

**R. Dagit**. RCDSMM, PO Box 638, Agoura Hills, CA 91376

In 1995 the RCDSMM needed help removing trash and answering questions about water quality in Topanga Creek. Starting with a small group of interested volunteers, the Topanga Creek Stream Team measured rainfall, flow and nutrients throughout the watershed. From this humble beginning, the crew expanded into surveying bats under the bridges, frogs, turtles, snakes and macro-invertebrates in the creek, mapping tree locations to develop fire safe landscaping strategies, removing invasive plants and animals, and assisting with the trapping and monitoring of endangered fish. In 2000, we orchestrated a massive creek clean up, using a helicopter to airlift 22 wrecked cars and 17 loads of trash from the creek. Expanding mostly by word of mouth, the Topanga Creek Stream Team now has more than 150 members. We are proud that many of the students who volunteered with us have moved into college and careers that continue their contributions to environmental sustainability.

## 30 HEAL THE BAY'S STREAM TEAM: SCIENCE, POLICY OUTCOMES, AND STEWARDSHIP RESULTS FROM 16 YEARS OF CITIZEN SCIENCE

**K.M. Pease** and S.A. Sikich. Heal the Bay, Santa Monica, CA, 90401

Heal the Bay initiated its Stream Team citizen science program in 1998 to collect water quality and riparian habitat data, identify stressors, and assess the health of the Malibu Creek Watershed in the Santa Monica Mountains of southern California. The Malibu Creek Watershed is the second largest watershed draining to the Santa Monica Bay and is one of the last watersheds in the area that has considerable amounts of natural habitat. Volunteers are trained by scientists at Heal the Bay in water quality and biological monitoring protocols. Over the course of Heal the Bay's Stream Team program, staff and volunteers have spent over 40,000 hours collectively monitoring water quality and habitat health. Data collected through the Stream Team program go through rigorous quality assurance and quality control protocols to ensure a high standard. Despite minimal development in the watershed, we find evidence of degradation such as hardened streambanks, polluted waterways, and invasive animals and plants. Data from the Stream Team have been used to advance numerous policies and regulations, such as placing stream reaches on the Clean Water Act section 303(d) list of Impaired Waterbodies for California and in the development of total maximum daily loads (TMDLs). Heal the Bay's Stream Team program has been extremely successful at engaging and utilizing volunteers to conduct high quality research with applied outcomes, serving as a case study of a robust citizen science program with proven application for resource management.

## 31 CITIZEN SCIENCE ON THE BEACH: LESSONS LEARNED AND NEW OPPORTUNITIES

**K.L.M. Martin** and M. Studer. Department of Biology, Pepperdine University, Malibu, CA 90263. Beach Ecology Coalition, Malibu, CA 90263

Even the most urbanized beaches of southern California retain some ecological functions. For example, local beaches are essential spawning habitat for the California Grunion, an endemic marine fish. Grunion runs occur following night time high tides, across southern California, after the full and new moons of spring and summer. In 2001 San Diego residents expressed concern over the impact of the City's beach grooming practices on grunion eggs beneath the surface of the sand. A team of volunteers, the "Grunion Greeters," offered the most feasible and cost effective method for collecting data about grunion runs on many different sandy beaches simultaneously. Since 2002, the program expanded throughout the species' entire habitat range. Over 4000 citizen scientists provided data from over 100 observation sites, and educated the public about the ecology of the grunion and sandy beach habitats. This resulted in positive changes in beach management and greater involvement of stakeholders in policy development. New beach management practices are in place throughout the California, with cooperation of California Coastal Commission, National Marine Fisheries Service, California Department of Fish and Wildlife, California State Parks, and local governments and NGOs. The lessons learned from working with a large group of geographically distant volunteers, and the keys to the program's success can be employed to develop new

methods. A new program to monitor beaches for ecological function will build on this existing network and create a more comprehensive outreach for citizens to increase scientific knowledge about the sandy beach ecosystem.

## 32 BIOGAMES: A PLATFORM FOR CROWD-SOURCED BIOMEDICAL IMAGE ANALYSIS AND TELE-DIAGNOSIS

**A. Ozcan**. UCLA Electrical Engineering and Bioengineering Departments

We recently proposed a mathematical framework for crowd-sourcing of biomedical image analysis and diagnosis through digital gaming. In this talk we will discuss our recent progress on this gaming platform and demonstrate its viability for tele-diagnosis of malaria achieving an accuracy that is within less than 2% of a trained expert's.

## 33 THE LA MAKERSPACE AND THE ROLE OF CITIZEN SCIENCE IN EDUCATION

**A.L. Simons**. P.O. Box 65756 Los Angeles, CA 90065-0756

The LA Makerspace is an all-ages community workspace with a focus on outreach in various technical and design fields ranging from programming, to movie making, to molecular gastronomy. A large portion of our efforts over the past two years has been managing a citizen science program for students out of a community lab space in Los Angeles. This has involved students from a number of Los Angeles high schools working with both universities conducting research, such as USC and Caltech, as well as non-profit groups which are involved in research, such as Safecast and the Natural History Museum of Los Angeles. A highlight of these projects illustrates a model of how to mutually engage both the education and research communities. Future directions for the program, such as formal support for teachers as well as students, are also considered.

## 34 RECLASSIFICATION OF CALIFORNIA PIPEFISHES (SYNGNATHIDAE)

**C.A. Rice**, D.J. Eernisse and K.L. Forsgren. California State University, Fullerton Department of Biological Science 800 N. State College Blvd. Fullerton, CA 92834

California pipefishes are highly diverse and particularly difficult to consistently identify. The widely used Miller and Lea Guide To The Coastal Fishes of California does not include all of the recognized Californian province species. We reexamined the key morphological traits emphasized in pipefish keys seeking to improve the diagnostic separation of pipefish species. Our data indicate that certain features, such as barred markings or a truncated snout, are reliable in separating three recognized species in California; kelp pipefish (*Syngnathus californiensis*), barred pipefish (*S. auliscus*), and snubnose pipefish (*Cosmocampus arctus*). In contrast, a combination of morphological and mitochondrial 16S and COI analyses have so far not supported three currently recognized species as distinct: the bay pipefish (*Syngnathus leptorhynchus*), and barcheek pipefish (*S. exilis*), and all could be synonymous with *S. californiensis*. Future work will further test these conclusions and our goal is to produce a more useful dichotomous key to California pipefishes. We expect to add more pipefish localities and species sequence comparisons and extend what we learn to also better characterize the identification of juveniles. The results from this study will be beneficial to fishery biologists working in the field to more effectively identify pipefishes.

## 35 STATUS OF THE ENDANGERED SCOTTS VALLEY SPINEFLOWER (POLYGONACEAE) IN COASTAL CENTRAL CALIFORNIA

**C.P. Kofron** and K. Lyons. U.S. Fish and Wildlife Service, Ventura, CA 93003; Biotic Resources Group, 2551 South Rodeo Gulch Road, #12, Soquel, CA 95073

*Chorizanthe robusta* var. *hartwegii* (Scotts Valley spineflower, Polygonaceae) is a narrow endemic plant restricted to a specialized microhabitat (exposed bedrock in California prairie) in Santa Cruz County, California. This taxon and the nominate variety were listed as endangered under the U.S. Endangered

Species Act in 1994. Three occurrences of *C. robusta hartwegii* exist on four properties in a recently urbanized area at the northern edge of the city of Scotts Valley. Ten of 80 known colonies are now likely extirpated. In 2014 the primary threats are habitat alteration due to adjacent land uses and developments, and invasive plant species (non-natives) and accumulation of thatch. Using international standards, *C. robusta hartwegii* is critically endangered: area of occupancy, 0.39 ha; extent of occurrence, 1.3 sq km; landscape, severely fragmented; and quality of the habitat, continuing to decline. With these attributes, *C. robusta hartwegii* faces a n extremely high risk of extinction. As a matter of urgency, we recommend reducing and controlling invasive plant species and thatch using a combination of methods: mowing with biomass removal, cutting by hand tools with biomass removal, pulling by hand with biomass removal, controlled grazing, prescribed mini-burns (testing 1 sq m), and spot-treating invasive grasses with a grass-specific herbicide.

## 36 GEOSPATIAL ANALYSES OF PLANT INVASION AND HABITAT TRANSGRESSION WITHIN AN IMPACTED ECOLOGICAL RESERVE

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Substantial impacts to the 600 acre Ballona Wetlands Ecological Reserve (BWER) including the channelization of Ballona Creek, excavation of Marina del Rey, and construction of bisecting thoroughfares have altered the distribution, extent, and nativity of vegetation communities. Mapping data dating back to 1876 have depicted the BWER as a native-dominant estuarine wetland complex; however, more than a century of human abuse resulting in the deposition of fill soils, impaired hydrologic connectivity, and fragmentation have facilitated the propagation of non-native plant species. This paper compares recent vegetation mapping surveys (i.e. 2007 and 2013) to geospatially quantify plant invasion over time and identifies susceptible habitat areas. Field methods for both mapping efforts were conducted in accordance with methods created by the California Department of Fish and Wildlife's Vegetation and Classification Mapping Program. Polygons were field classified by vegetation alliances and subsequently crosswalked into habitat types. Summary results indicate habitat type conversion and species invasion between survey years is greatest within more impacted areas (e.g. hydrologic impairments, deposition of fill soils) while native communities appear relatively stable within other areas. While analyses indicate species invasion may be area-specific, site-wide trends demonstrate that within six years, areas dominated by highly invasive species have increased including: *Euphorbia terracina* (5.83 acres), *Carpobrotus edulis* (4.99 acres), and *Cortaderia selloana* (1.02 acres). These data will be applied to assess and identify potential at-risk habitat areas to be targeted by future restoration projects and long-term management strategies for the site.

## 37 COMPARING SEED VIABILITY AND HARVEST CONSISTENCY ACROSS SITES AND YEARS FOR THE FEDERALLY ENDANGERED PLANT *ERIASTRUM DENSIFOLIUM* SPP. *SANCTORUM*

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The Santa Ana River woolly star, *Eriastrum densifolium* spp. *sanctorum*, is a federally-listed, endangered plant species native to the Santa Ana River floodplain in Redlands, CA. Woolly star has a specific habitat preference for young sand deposits that develop after periodic flooding. A major reason for its protection is the lack of such flooding from the Santa Ana River due to regional flood control measures. Suitable woolly star habitat is now significantly reduced and only supports small populations. A seed reserve of approximately 77,000 viable woolly star seeds were collected as part of a larger project that will simulate a small flood in an attempt to artificially generate new woolly star habitat. Seed collections involved formalizing a method for harvesting, sorting, counting, testing viability, and storing the seeds. The methods were tested at three sites and across two years with slightly lower-than-normal precipitation (2012 and 2013). Our objective was to achieve consistent and reproducible seed recovery across years and sites. Variation across sites was larger than expected, but recovery between years was consistent. Our results indicate that the harvest method appears to be reliable for consistent seed recovery, but that seed production differs significantly between sites.

## 38 WILDLIFE TROPHIC DYNAMICS AND IMPLICATIONS IN AN URBAN NATURE PRESERVE

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In many urban ecosystems, trophic dynamics are evolving with the increase of mesopredators like coyotes, raccoons, skunks and the decrease of top-down predators such as wolves. This study examined the dynamics of wildlife and outdoor cat movement present at Royal Palms Park and White Point nature preserve in Palos Verdes. The goal of the study was to better understand how the wildlife present at the nature preserve interact. Specifically looking at temporal movement patterns of feral cats and native mammals into/out of the nature preserve. Camera traps were placed on an interpretive fence surrounding the nature preserve to quantify spatial and temporal movement patterns of wildlife and outdoor cats. The results showed that foxes (40%), raccoons (49%), and feral cats (44%) have movement patterns toward the cat colony while coyote movement was primarily in the south direction (45%). All of the movement patterns showed significant p-values (coyote −0.0004, fox −0.0001, cat −0.0001, raccoon −0.0001) showing that the animals' movement was not random. Additionally, coyotes selected for 12 am – 4 am (p-value = 0.0001) as their primary movement period while cats were less active during that time showing a 30% reduction in presence (p-value = 0.0001). Also, the once crepuscular red fox shows a preference for nocturnal hunting with presence occurring between 8 pm and 4 am (p-value = 0.0001). The urban-wild interface can cause an evolution of trophic dynamics especially between predator and prey. Understanding these changes is essential for management of our urban wildlife.

## 39 URBAN/SUBURBAN HABITAT USE BY A NATIVE AND INVASIVE TREE SQUIRREL

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The Eastern Fox Squirrel has been introduced to Los Angeles and other areas within California. Over time, the fox squirrel has expanded its geographic range and has displaced the native Western Gray Squirrel in many urban/suburban habitats. Possible reasons for displacement could be differences in habitat, space, and/or resource use by each species. Habitat use is defined as the way an animal uses the habitat's physical and biological resources through its environmental components and the animal's behavior. I tested gray and fox squirrels in their willingness to approach novel food sources and exploit them away from the protective refuge of trees, thereby utilizing more space and resources but increasing predation risk. Daily activity of both species was documented to determine similarities and differences in their use of time within the habitat during the summer and winter seasons. A significant difference in approaches to novel food items was found between the two species. No differences were found in daily activity during the summer season and winter observations are ongoing. Other portions of this study include food preferences and monitoring reproductive activity. These results provide information on the coexistence of gray and fox squirrels and potential reasons for gray squirrel displacement.

## 40 FIRE AND NO RAIN: REDUCED VERTEBRATE AND INVERTEBRATE ABUNDANCE AND DIVERSITY IN THE WAKE OF THE 2013 CAMARILLO SPRINGS FIRE

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The May 2013 Camarillo Springs Fire burned 9,809 hectares (24,238 acres) in the western Santa Monica Mountains over a five day period. While few university buildings burned, the entirety of our California State University Channel Islands campus burned on the morning of May 2, including all of our long-term monitoring sites proximate to Calleguas Creek. Fortuitous camera trapping and insect sampling immediately prior to the burn and subsequent post-fire monitoring have provided us with a somewhat unique opportunity to study the effects of this fire on animal abundance and diversity. Larger vertebrates

(carnivores, cervids) were little affected initially. In contrast, smaller vertebrates (lagomorphs, rodents, etc.) were much less abundant in the days and weeks post-burn. In the months since the fire, all vertebrate encounter rates have declined to rates well below both initial post-fire and previous year levels. Insects showed a much more diverse fire response; invertebrate biomass was initially unchanged by the fire, however diversity dropped in the wake of the burn. Post-fire generalist invertebrates appear to be more successful relative to more specialist functional groups. We are continuing to monitor our sites, however long-term effects of the Springs Fire are complicated by our intensifying drought (currently the lowest rainfall since documentation began in 1887). This intense, early season fire coupled with extremely low rainfall appears to be dramatically reducing the number of animals across our study sites with potentially long-term consequences for ecosystem functioning.

## 41 EXAMINING ANURAN DECLINES IN SOUTHERN CALIFORNIA'S WESTERN TRANSVERSE RANGES: DID DISEASE PLAY A ROLE?

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Southern California's anuran diversity is dominated by species of special conservation concern. While many causative factors have been implicated in declines of anurans in California, none are able to adequately account for population declines in backcountry areas removed from predominating anthropogenic impacts, except disease. In California and elsewhere in the world, amphibians have declined in relatively pristine areas due the potentially fatal disease, chytridiomycosis, caused by the pathogenic chytrid fungus *Batrachochytrium dendrobatidis*. To investigate the possible role of the chytrid fungus in anuran declines in backcountry areas of southern California, we have sampled the anuran community assemblage at several stream sites in the Western Transverse Ranges for the chytrid fungus. Here, we present trends in our data to date and discuss our methodologies for examining the emergence of the pathogen in the study area through time.

## 42 CITIZEN SCIENCE: FINDING A MATCH FOR THE MULTI-AGENCY ROCKY INTERTIDAL NETWORK (MARINe)

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Citizen science groups, due to a confluence of increased public interest in coastal areas and declining public funding for research, have gained popularity in recent years as a mutually beneficial arm of coastal research programs. The Multi-Agency Rocky Intertidal Network (MARINe) program is interested in the applicability of citizen science for this long-term monitoring effort along the Pacific coast. A widespread outbreak of seastar wasting disease was noted in the summer of 2013, and MARINe enlisted citizen science groups to collect data to quickly supplement our knowledge of the extent of the disease. This paper will relate our experience to date with these groups. Ultimately, MARINe envisions that citizen science groups using a simplified MARINe surveying protocol can collect data to supplement data collected by MARINe scientists. Several MARINe partners already conducting citizen science as a part of their group's mission have volunteered to pilot a few new MARINe citizen science sites in the Pacific Northwest and in central and southern California. MARINe is planning to evaluate concurrent data collection by different types of citizen scientists (high school students, retired scientists, and rocky intertidal reserve docents) and by MARINe scientists to better understand which group characteristics and factors are the most important in ensuring the appropriate data collection for MARINe. MARINe hopes to use citizen scientists long-term at a few locations where funding has lapsed and groups are well-positioned to carry out a monitoring effort.

## 43 ECOLOGICAL CONSEQUENCES OF INCREASING ENVIRONMENTAL VARIABILITY ON ROCKY SHORES

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Increases in average temperature due to anthropogenic global warming have already been implicated in changes in population dynamics, species interactions, and community structure from local to global scales. Higher temperature variability is likely to be an additional driver of biological disturbance, as it increases the risk that species' tolerance limits will be exceeded. To explore the potential effects of increasing temperature variation in a natural community, we implemented a novel manipulation to alter local thermal regimes in the marine rocky intertidal zone, a model system for the experimental investigation of organismal responses to environmental stress. We measured through time the physiological and demographic responses of a guild of congeneric grazing limpets (marine snails), the productivity of their benthic microalgal food, and the resulting interaction strengths between the two taxa. There were marked differences in the responses of different limpet species to our experimental manipulation. For example, growth of *L. scabra* was negatively related to daily temperature range, whereas the other species showed no effect of thermal variation. Across a range of temperatures, high-intertidal species exhibited consistently lower respiration rates during aerial exposure and higher upper thermal tolerance limits than mid-intertidal species. In the absence of grazing limpets, microalgal standing crop was negatively correlated with temperature variability; however, this pattern disappeared when grazers were present, regardless of limpet species identity or diversity. Our data suggest that characteristic differences in species-specific performance and resulting interactions may be a key determinant of ecological consequences of changing environmental conditions.

## 44 RECOVERY SOUTH-CENTRAL CALIFORNIA STEELHEAD

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The National Marine Fisheries Service (NMFS) listed in 1997 a Distinct Population Segment (DPS) of steelhead (*Oncorhynchus mykiss*) as threatened along the south-central coast of California. NMFS's Technical Recovery Team (TRT) for southern steelhead divided the South-Central California DPS into four Biogeographic Population Groups (BPGs), characterized by a distinguishing set of physical, climatic, and biologic features, reflecting the diversity of stream and watersheds within the DPS Recovery of the South-Central California DPS will require the restoration of a minimum number of viable populations within each of the four BPGs. The core watersheds identified in this biological strategy are geographically dispersed across the recovery planning area (extending from Monterey Bay to San Luis Obispo Bay) to preserve the existing diversity of history forms (ranging from anadromous to resident), and their evolutionary trajectories. Additionally, this strategy is intended to minimize the likelihood of extirpation of individual populations within each BPG by natural perturbations (ranging from droughts and wildfires to climatic changes), and allow the natural dispersal of fishes between watersheds. The South-Central California Coast Steelhead Recovery Plan also identified a suite of recovery actions for each core watershed intended to address threats currently facing the species, as well as future threats posed by climate changes, and related habitat transformations. Additionally, a long-term research and monitoring program is proposed to address a number of key issues (such as the relationship between anadromous and resident forms of *O. mykiss*) and refine the population and DPS-wide viability criteria developed by the TRT. Recovery will require re-integrating the listed steelhead populations into habitats in a manner that allows the co-occupancy of watersheds populated by almost 3 million people.

## 45 RESPIRATORY CONSTRAINTS RESTRICT YOUNG MYSTICETE'S ABILITY TO DIVE

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Physiological adaptations enhance the breath holding capacity of mysticetes, however in young mysticetes, the breath holding capacity is limited. In this study, we provide new details of aspects of the physiology of young mysticetes that may account for these constraints. Muscle tissue from stranded animals was analyzed to determine myoglobin concentration and muscle fiber type. Myoglobin is a protein that accumulates in the muscles of marine mammals and provides a store of oxygen that allows for extended breath holding capacity during dives. Different types of muscle fiber may also facilitate extended breath holding, by allowing the use of alternate respiratory pathways. Results indicated that myoglobin concentrations were lowest in the youngest animals and increased with age; levels of myoglobin in the youngest calves were less than 20% of adult levels. Fiber type also varied with age; type II muscle fibers

were prevalent in younger animals, but almost entirely absent in mature individuals. Based on these results, physiological factors constrain breath holding in young mysticetes. Further research on a full range of age cohorts will allow us to better quantify these changes. Understanding the dynamics of the development of the breath holding capacity will allow us to better predict the challenges that young mysticetes face in the changing marine environment. As climate change impacts the marine environment, the development of the breath-holding capacity in young and maturing animals may become crucial as availability and distribution of their food supplies fluctuate.

## 46 NON-LETHAL DETECTION OF SEX IN THE CALIFORNIA HALIBUT

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The primary goals of this project are to test a non-lethal method of determining the sex of California halibut (*Paralichthys californicus*) and to obtain samples in a way that avoids causing additional mortality to a significantly depleted resource. The halibut fishery is one of the state's highest priorities for developing a fishery management plan. However, the relative lack of sex-specific fishery data significantly hindered a 2011 stock assessment of the southern California halibut population. The accuracy of veterinary ultrasound in determining sex of halibut was determined using gross morphological comparisons between ultrasound sonography images and either visual inspection (in landed fish) or examination of genetic material (in live fish). The effects of reviewer experience were also assessed. Eighty-one fish were used in this study, ranging in size from 401 mm to 1090 mm. The non-lethal method was found to be 98.8% accurate with respect to visual identification and accuracy was found to increase with experience of the technician. Veterinary ultrasound is an acceptable method for identifying sex in California halibut. This method will enable sex specific data collection from landings in the commercial and recreational fisheries and other studies where this was previously impossible (tag-recapture studies). Ultimately, the California Department of Fish and Wildlife will be able to apply this additional sex-specific information to a much-needed stock assessment for California halibut. In addition, steps have been identified that can facilitate testing ultrasound for determining sex in other species of fish.

## 47 LATE MIOCENE "GREAT WHITE" SHARK FROM THE PUENTE HILLS, SAN BERNARDINO COUNTY, CA: RARE PRESERVATION OF VERTEBRAL CENTRAE OF A MARINE APEX PREDATOR (*CARCHARODON* SP., A LAMNIFORM ELASMOBRANCH)

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Fossil mako or white shark taxonomy is based primarily on tooth morphology, partially as a product of post-mortem loss of the cartilaginous skeleton and soft tissues. Although fossil *Carcharodon* (Linnaeus, 1758) teeth form a remarkable "bone bed" that concentrated on the Miocene seafloor over about a half million years at Shark Tooth Hill near Bakersfield, only a few isolated reports of lamnid shark teeth have been reported from Miocene Puente Formation in the Los Angeles Basin. No published reports of *Carcharodon* occur in the eastern Puente in a deep paleoembayment represented by the Upper Miocene Sycamore Canyon Member near its easternmost boundary in western San Bernardino County. Thirteen poorly mineralized vertebral centrae have been recovered from paleontological mitigation associated with housing development in the eastern Puente Hills. The centrae are embedded in a single block of fine-grained micaceous gray-green sandstone, are semi-articulated, and occur in two biometric sets: those over 60 mm diameter and those ranging between 45 and 54. The largest centrum is over 73 mm diameter, which indicates a minimal length of the shark between 4.5 and 6.5 meters. That's a big animal, and certainly one that terrorized the Miocene embayment in its lifelong search for nutrients. The Sycamore Canyon specimens correlate well with other discoveries of Pliocene *Carcharodon* vertebral centrae from Peru (Ehret et al., 2012) and Late Oligocene *C. angustidens* from New Zealand (Gottfried and Fordyce, 2001).

### 48 A COMPARISON OF ORGANIC POLLUTANTS IN *PARALABRAX NEBULIFER* (BARRED SAND BASS) FROM SOUTHERN CALIFORNIA

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Organic pollutants are persistent to the marine environment and can bioaccumulate in the tissues of organisms, especially in highly urbanized areas. The Southern California coast has historically been impacted by pollution. The Montrose Chemical company released millions of tons of DDT off the Palos Verdes Shelf from 1947–1970's, making it a superfund site. This study compares the concentration of organic pollutants (PCBs, PAHs, and OCPs) in tissues of a recreationally important coastal marine fish in Southern California. We tested for 107 different pollutants but only 77 were detected in barred sand bass. There was a significant difference in pollutant concentration among the four study sites, LA/Long Beach Harbor, Huntington Flats, San Clemente, and San Diego Harbor. Total OCP's differed significantly among sites, and DDT's constituted 98% of total tissue burden of OCPs. DDT burdens declined with distance from the Palos Verdes Shelf. Of DDTs, 4,4′- DDE constituted 9 7% of the total. More than 30 years have passed since Montrose chemical company stop manufactured DDT but organisms in the region are still being impacted. Tissue concentrations of PAHs and PCBs also differed among sites with highest tissue burdens found in fish collected in harbors. The relatively high concentrations of DDTs, PAHs, and PCBs in tissues of this popular sport fish are worrying and highlight the importance of monitoring fish from polluted sites to reduce human exposure.

### 49 'FEMALE' PROMISCUITY BENEFITS HERMAPHRODITES WITH VIOLENT MATING

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While the benefits to males of promiscuous mating are easily understood, female promiscuity (polyandry) is also common in nature. Fitness advantages of polyandry have historically been attributed to direct benefits such as 'nuptial gifts.' More recent studies have focused on indirect, or genetic, benefits such as increased heterozygosity. However, few studies have tested for benefits of polyandry in hermaphrodites, which often express male-advantage traits such as traumatic mating. I experimentally measured the fitness effects of polyandry versus monogamy in two hermaphroditic sea slugs (*Alderia willowi* and *A. modesta*). In both species, mating by hypodermic insemination imposes high fitness costs; *A. willowi* may also be susceptible to inbreeding, especially early in colonization events, due to local recruitment of short-lived planktonic larvae. I manipulated mating opportunities and degree of relatedness to test whether polyandry offset costs of mating or inbreeding. In both species, slugs in polyandry treatments laid significantly more eggs and produced larger larvae compared to monogamous slugs, revealing fitness benefits of polyandry for both mothers and offspring. In *A. willowi* costs of traumatic mating caused a linear decrease in egg production in proportion to mating frequency for monogamous slugs. However, polyandry rescued the fitness of slugs in high-frequency mating groups. Finally, polyandry offset costs of inbreeding depression among half-sibling, which produced significantly more eggs than monogamous half-siblings and had increased hatching success. This study supports hypotheses based on sexual selection theory by demonstrating that polyandry benefits the female function of hermaphrodites, and offsets costs of mating due to traumatic insemination.

## POSTER SESSION ABSTRACTS IN PROGRAM ORDER

### 50 ASSESSMENT OF INVASIVE NEW ZEALAND MUDSNAIL ABUNDANCE ON JUVENILE MAYFLY POPULATIONS WITHIN THE MALIBU CREEK WATERSHED

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New Zealand mudsnails (*Potamopyrgus antipodarum*) have been unintentionally introduced throughout the world, are able to reproduce quickly, and are found in extremely high densities. However, the ecological impacts of New Zealand mudsnails are not well understood. Utilizing Heal the Bay's citizen science bioassessment data, we examined the impact of New Zealand mudsnails on benthic macroinvertebrates in the Malibu Creek Watershed. The introduction of New Zealand mudsnails to the

Malibu Creek Watershed in 2005 has correlated with the decline of a number of native benthic macroinvertebrates. Specifically, larval mayfly populations have shown a consistent decrease in Malibu and Medea Creeks. To determine if New Zealand mudsnails are causing this decrease, we performed a multiple regression analysis in R on data spanning from 2001 to 2012. We examined the impact of New Zealand mudsnail abundance on the abundance of mayflies, including other possible explan atory factors in the model such as dissolved oxygen, conductivity, average annual precipitation, and human disturbance. We found that New Zealand mudsnail abundance was the primary predictor attributing to negative mayfly abundance. The results indicate that the establishment of the invasive New Zealand mudsnail has detrimental effects to the native fauna of the Malibu Creek Watershed.

## 51 THE CALIFORNIA NATURALIST PROGRAM

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University of California's California Naturalist Program seeks to create a committed corps of volunteer naturalists and citizen scientists trained and ready to take an active role in natural resource conservation, education, and restoration. Throughout the nation, Master Naturalist programs and citizen science projects have both been shown to increase volunteers' ecological knowledge, understanding of science, and environment-related behaviors. In California, we partner with local organizations to offer the course. Our partners utilize a core science curriculum called the California Naturalist Handbook (published by UC Press) that addresses basic natural history of California as well as classical and modern techniques for recording observations of nature. Our program includes hands-on learning, communication training, and community service to engage participants in interactive learning and provide them with scientific literacy and critical observational, analysis, and interpretation skills. We are currently developing advanced curricula in subjects such as the ecology of specific bioregions, near shore systems and the California Current, and urban ecology. To date, we have partnered with 15 organizations to certify 470 Naturalists, who have volunteered 9700 hours of service in program support, interpretation, scientific study, and restoration.

## 52 DEVELOPING A NEW METHOD FOR CITIZEN SCIENTISTS TO ASSESS SANDY BEACH ECOSYSTEMS

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Traditionally managed as recreation areas, beaches are also important natural ecosystems, a link between marine and terrestrial environments. Many animals and plants depend on this unique habitat for critical periods of their lives. With so many different human activities, urban beaches may have the most frequent disturbance regime of any marine ecosystem. Many common management practices and coastal industries impact the inhabitants and ecological functions of the sandy beach ecosystem, but data to evaluate impacts is difficult to acquire. To address this need, in California, USA, participants from academic, government, environmental, and educational organizations are working to develop a consistent, useful set of indicators for scientists and the public to assess beach ecosystem status and trends. A key goal of this project is to involve the public in local, community-based monitoring of sandy beach ecosystems. Areas rich in natural resources will be surveyed along with other areas that are subject to intense human use. For each beach site, an assessment of current or baseline state of the natural environment will contribute to observations of status, trends, and changes over time. The initial few pilot sites will lead to a regional baseline survey of conditions in southern California. This will enable evaluation of impacts of anthropogenic and natural events, and provide tools for conservation. Funded by USC SeaGrant Urban Oceans Initiative, Whale Tail, and Edison International Community Grants.

## 53 RIVERSIDE CITIZEN SCIENCE: LEADERSHIP FROM MUNICPAL, UNIVERSITY AND FEDERAL PROGRAMS PLAN AND LAUNCH A COMMUNITY-BASED NATURAL RESOURCES MONITORING AND STEWARDSHIP EFFORT

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As California moves toward a majority of its population living in urban settings, investments in programs which engage new and better-informed audiences in nature study hold the potential to improve the documentation of environmental change and encourage stewardship activities in the wildlands and open spaces impacted by urban development. Beginning in 2004, with leadership from the Smithsonian Institution, a coalition of Riverside, CA stakeholders held a series of symposia, workshops and public programs to assess the interest of science, recreation, resource management and education communities in a formal Riverside Citizen Science (RCS) effort. Following an enthusiastic response, a working group (guided by technical assistance from the National Park Service) began assembling an RCS strategic plan, and the City of Riverside was awarded over $800,000 in State grants to create a dedicated facility and staffing. The City has developed and published a smartphone application intended to allow users to log their nature observations with the RCS program, and will otherwise promote sharing of experiences through social media and in-person activities. In partnership with the USDA Forest Service, RCS will be undertaking a multi-component evaluation to determine the extent to which these activities engender increased interest in and awareness of nature within the city, especially among youth audiences, and thus inform future program development.

## 54 CORRELATING SECONDARY PRODUCTIVITY AND HABITAT COMPOSITION OF EELGRASS BEDS IN A SOUTHERN CALIFORNIA MARINE PROTECTED AREA

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Big Fisherman's Cove off Santa Catalina Island is designated as part of the Blue Cavern State Marine Conservation Area under the California Marine Life Protection Act. As a no-take zone, it is designed to preserve the habitat of invertebrate and fish species, as well as supporting surrounding populations. However, there is a paucity of data linking secondary production in MPA nurseries to bolstered reserves of game fish. This study aims to establish a relationship between juvenile fish populations in eelgrass beds and eelgrass robustness. Juvenile kelp bass (*Paralabrax clanthratus*) were the primary fish observed in our study. Eelgrass robustness was recorded using eelgrass density and eelgrass length in conjunction with overall eelgrass cover (percentage of habitat composition). Over time, the number of *P. clanthratus* declined, which correlated with a decrease in eelgrass density. As expected, other species of fish observed in this study followed a similar pattern. There was no correlation between the number of *P. clanthratus* and their recorded length over time. These data will provide a better understanding of the characteristics and stability of eelgrass communities within Big Fisherman's Cove, as well as provide important information about the ecosystem health of the Blue Cavern State Marine Conservation Area at large.

## 55 LONG-TERM FISH COMMUNITY STABILITY IN URBAN ESTUARINE EELGRASS HABITAT

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Anthropogenic stressors have diminished the size and quality of coastal estuarine habitats in Southern California over the past century. However, there are few long-term datasets with which we can track

biological changes associated with increasing urbanization and associated press disturbances. Eelgrass fish communities were sampled by beach seining at two urban coastal estuaries, San Diego Bay and Mission Bay, from 1987-2010. Fish communities are ideal for tracking changes in habitat quality because they encompass a range of life histories and functional guilds and may disperse from stressed habitats. Data were analyzed for changes in community stability over time using mean rank shift and time lag analysis. Community differences across time of day and season and the influence of abiotic variables were analyzed with ANOSIM and BIO-ENV, respectively. All indices suggested communities were not shifting to a new assemblage, with the exception of the rare fish community in Mission Bay. Communities were significantly different across season and sampling time, but were not well correlated with abiotic factors. Given that development of these estuaries has occurred over a long time period, and that San Diego Bay experienced improvements in water quality during the 1970's, it may be that these communities shifted to a new assemblage structure prior to the onset of sampling. Additionally, eelgrass habitats may provide a form of refuge from the press disturbances in urban ecosystems by locally improving water quality and decreasing turbidity. This work highlights the importance of both long-term sampling efforts and preservative of sensitive habitats, such as eelgrass, in disturbed systems.

## 56 THE ENIGMATIC PACIFIC BRITTLE STAR GENUS OPHIOTYLOS: REOPENING A TAXONOMIC 'COLD CASE'

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We collected specimens of *Ophiotylos* from Hawaii, vastly extending the known range of a brittle star genus comprising two nominal species: *Ophiotylos leucus* and *O. brevipes*. *Ophiotylos leucus*, the type-species of the genus, was discovered in Palau by Murakami in 1943, and *Ophiotylos brevipes*, which, based on one specimen from the South China Sea, was described by Liao in 1978. To determine if animals from Hawaii are conspecific with *O. leucus*, we needed to compare them with fresh specimens from Palau (as the type-series of *O. leucus* was lost long ago). Recently, we rediscovered and sampled the Palauan population and found that Palauan and Hawaiian individuals brood their young, raising the question of how, without a dispersive larval stage, they spread between distant islands. Based on data presented in this study, we show that *Ophiotylos* from both populations can be reliably distinguished from one another. *Ophiotylos leucus* appears to attain a larger body size than *Ophiotylos* sp. from Hawaii, and individuals from both localities undergo marked morphological changes during ontogenesis. Distinctions between *Ophiotylos leucus* and *Ophiotylos* sp. of equivalent size include a relatively smaller central plate, as well as narrower interradial disk plates. *Ophiotylos leucus* has 1 tentacle scale on its basal arm joints and 3 oral papillae, whereas *Ophiotylos* sp. has 2 tentacle scales and 4 oral papillae. Additionally, *O. leucus* has reddish pigment spots that are lacking in *Ophiotylos* sp. By studying the specimens of *Ophiotylos* at hand, and perhaps from additional localities, we hope to better understand its systematics, evolution, and ecology.

## 57 THE CLEAN WATER TEAM AND CITIZEN SCIENCE ACTIVITIES WITHIN CALIFORNIA'S WATERSHEDS

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Citizen science activities within the nation's watersheds date back over 100 years when the National Weather Service Cooperative began recruiting volunteers (1890) to report daily measurements of rainfall and air temperature, the National Audubon Society started its Christmas Bird Counts (1900) and the Izaak Walton League of America kicked off volunteer water monitoring with volunteers and conducted the first national water survey for President Calvin Coolidge (1920). Like many states California supports Citizen Science. In 1999 the SWRCB established the Clean Water Team (CWT) to assist citizen monitoring of water quality (chemical, physical, biological, ecological). CWT assists the citizen monitoring community through training, SOPs, QA/QC, data management, loans of equipment, event promotion, communication and facilitating state of the art monitoring solutions. Citizen monitoring activities are actively protecting and restoring California's waters through actionable data and science based stewardship.

## 58 AGE AND GROWTH OF THE GIANT KELPFISH (*HETEROSTICHUS ROSTRATUS*)

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Giant kelpfish, *Heterostichus rostratus*, are found within kelp forests stretching along the west coast north to British Columbia and south to Cape San Lucas, Baja California, Mexico (Roedel 1953). While *H. rostratus* are one of the largest and most abundant members of the clinid family, relatively little current literature exists on this species. Past life history research has resulted in parameters that vary across studies, likely due to differences in methodology. To better understand the life history of *H. rostratus*, approximately 300 individuals were collected using trawls and beach seines in San Diego Bay and by spear in nearshore kelp forests in southern California. After removing and reading otoliths for growth increments, von Bertalanffy, Gompertz, and power functions were used to estimate growth rates for juveniles and adults. Establishing the length-weight relationship, standard length to total length relationship, and determining age and growth parameters are important for future fish production studies in Southern California and can be used to analyze results of non-extractive visual fish surveys that only measure total length.

## 59 POST-FIRE AVIAN DIVERSITY ON CSU CHANNEL ISLANDS CAMPUS

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Avian diversity is an important metric in monitoring the health of many ecosystems. Since opening in 2002, the CSU Channel Islands campus has not been systematically surveyed for birds. The federally and state endangered least Bell's vireo and the federally threatened coastal California gnatcatcher have been recorded on campus. Several bird species designated as 'special status' also have been recorded on campus, including one of only three aggregations of the coastal cactus wren. The Springs fire that occurred in May 2013 completely surrounded the campus and severely damaged nesting areas for the coastal cactus wren and the coastal California gnatcatcher. There are several bird species that were present on campus prior to the fire but whose status is unknown at this time. However, since the fire we have recorded over 100 bird species (46 families). Our study will continue to track the avian community as it responds to the changes in the post-fire vegetation.

## 60 DISTRIBUTION OF INTRODUCED TREE SQUIRRELS IN CALIFORNIA – A CITIZEN SCIENCE APPROACH TO GATHERING DATA

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Providing an accurate and detailed description of the distribution of a species within a defined geographic area is difficult. Previous studies on species distributions have used location data from specimens maintained in collections at universities or museums. However, past practice is not useful when working with introduced species because few specimens are present in managed collections. In this study we describe a new method for establishing the current and historical range of two species of introduced tree squirrels in California. The method involves the collection of location data from wildlife rehabilitation facilities, and from individual citizens who use an application on a smart phone. We provide geographic range for the eastern fox squirrel (*Sciurus niger*) and the eastern gray squirrel (*Sciurus carolinensis*) in California with location points at this time of approximately 4700 for *S. niger* and 1200 for *S. carolinensis*. Large sample sizes allow for detailed mapping of the distribution of each species. Also, assessments related to habitat use and future range expansion can be made through the use of geographic information software. Current data show two large populations of *S. niger* within California. The first population extends north, south, and east of San Francisco while the second population extends north, south, and east of Los Angeles. A continuous geographic range for *S. carolinensis* extends from Monterey northward to Sonoma and Rohnert Park. Use of location data from rehabilitation facilities and from citizens using smart phones may be useful for studying many species.

## 61 A THREE DIMENSIONAL COMPARISON OF ONTOGENY IN TWO MORPHOTYPES OF CAMBRIAN AGNOSTID ARTHROPODS

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The Late Cambrian Agnostid genus *Pseudagnostus* from the U.S. Great Basin exemplifies a morphotype wherein pygidia expanded rapidly during ontogeny. We document its expansion using Z-stacking microscopy, a technology that facilitates both volumetric measurements and qualitative comparisons. The genus is contrasted with the genus *Peronopsis*, an exemplar of an earlier, axialobate morphotype with a dramatically lesser rate of expansion. Smallest early holaspid *Pseudagnostus* pygidia do not show axial inflation before expansion of the lateral areas of the acrolobe. Rather, they show expanded lateral areas inflating early, while the anteroaxis remains depressed, followed by expansion of a wide deuterolobe area, a posterolateral region vaguely defined by accessory furrows. In contrast, small *Peronopsis* exhibit a rapid and distinct rise of the axial area, followed by moderate inflation of areas lateral to it. The ontogeny and adult allometry of *Pseudagnostus* merit study because the genus persists across a Late Cambrian extinction boundary. We hypothesize that expanded volume in the early-expanding pygidia accommodated early expansion of the uniquely clubbed appendages, and gave *Pseudagnostus* a selective advantage given significant oxygen fluctuation in the Late Cambrian.

## 62 ECOLOGICAL DISTRIBUTION AND RADULA MORPHOLOGY OF THE GIANT KEYHOLE LIMPET (*MEGATHURA CRENULATA*).

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In southern California, the giant keyhole limpet (*Megathura crenulata*) is an important emerging fishery that has grown in commercial and scientific importance in the last twenty years. Giant keyhole limpet hemocyanin (KLH) shows promising biomedical potential, yet scant ecological information and limited fishery regulations question whether wild limpet stocks can satisfy a growing commercial demand. In order to aid sustainable management practices and predict appropriate aquaculture techniques, this study examines the giant keyhole limpet from an ecological and morphological standpoint. Benthic data was collected by SCUBA and modified standard CRANE methodology in four depth zones of 11 reefs along the Palos Verdes Peninsula. Specimens collected in the field and obtained from Stellar Biotechnologies at body sizes ranging from <1 mm to 12 cm were dissected and radulae were processed for scanning electron microscopy (SEM). Species abundance and size frequencies were compared to abiotic and biotic reef characteristics and radula morphology was examined during development from post larva to mature adult. Ecological and morphological data suggest that giant keyhole limpets prefer shallow waters, bedrock substrate, and high relief and transition from microbe consumers to opportunistic omnivores during development from post larvae to adult. These results characterize factors influencing the giant keyhole limpet fishery and examine radula structure and function, serving as the first step toward implementing sustainable management practices and aquaculture techniques.

## 63 BIODIVERSITY STUDIES USING LARGE-SCALE INSECT SURVEY IN THE LOS ANGELES BASIN

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Biodiversity Science: City and Nature (BioSCAN) is a three year, large-scale investigation into the biodiversity of insect species in the Los Angeles basin conducted by the Natural History Museum of Los Angeles County. Weeklong samples are collected continuously using 30 Malaise traps positioned across an urban-to-less-urban swath of Los Angeles. Each of the 30 BioSCAN sites consists of a Malaise trap and a microclimate weather station. BioSCAN has collected over 400 samples since December 2013. These samples are helping to shed light on the comparative diversity of insects in an urban environment. We have

initiated in-depth analysis of dipteran families of interest, focusing on drosophilid (Diptera: Drosophilidae) and phorid (Diptera: Phoridae) species. We are interested in better understanding the diversity of these groups both across space, and through time in the Los Angeles basin.

## 64 THE EFFECT OF ANTHROPOGENIC NOISE ON THE TERRITORIAL BEHAVIOR AND SONG OF ANNA'S HUMMINGBIRD (*CALYPTE ANNA*)

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As humans encroach upon natural habitats, we present animals with a novel acoustic background in which to forage, communicate, and reproduce. Numerous studies have explored noise-driven vocal adjustments, but studies on non-vocal behavioral modification are scarce and patchily distributed across taxa. Songbirds feature heavily in the literature on vocal adjustment, but less is known about how other avian groups respond to noise. I explored the relationships between background noise and both behavioral and vocal metrics in Anna's Hummingbird, *Calypte anna*, a non-passerine vocal learner. My analysis spans a broad noise gradient from below 40 to nearly 70 dB, mainly driven by traffic noise. Males in noisier locations flew off their territories more often and sang at a lower rate when present. As noise increased along the gradient, songs were longer and had slightly higher minimum frequencies, although peak frequency did not change. In higher noise, males al so demonstrated slight trends to groom and feed less and chase and dive more, suggesting higher vigilance and visual territory defense. These relationships did not hold across noise gradients within each park, but the correlations were strong when noise levels and response variables were averaged for each park. Such responses on a population level suggest an ontogenetic or evolutionary shift rather than individual plasticity. Additionally, songs of males from each park were visually similar regardless of noise, supporting tutor-learned or hereditary transmission rather than noise-matching habitat settlement or post-dispersal adjustment. The observed responses have potential energetic and reproductive consequences for hummingbirds in noisy habitats.

## 65 RED SWAMP CRAYFISH (PROCAMBARUS CLARKII) IN TOPANGA CREEK: REMOVAL EFFORTS AND ECOSYSTEM EFFECTS

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The presence of invasive red swamp crayfish (*Procambarus clarkii*) in Topanga Creek was first recorded in 2001. The population has since increased, with an apparent explosion in 2012 during an extended period of low flow. Within the Santa Monica Mountains, *P. clarkii* has been linked to diminishing numbers of California newt (*Taricha torosa*), a species of special concern. But just how far-reaching are the effects of this non-native in Topanga Creek? Does the presence of *P. clarkii* have adverse effects on water quality, endangered steelhead trout (*Oncorhynchus mykiss*), or benthic macroinvertebrate assemblages? And if so, can removal efforts be sustained effectively? To address these concerns, we led a student citizen science program from September 2013 through February 2014 to remove crayfish from a 200 m reach of Topanga Creek. We collected and compared the following metrics between the removal reach and an upstream, adjacent 200 m non-removal reach: water quality (temperature, salinity, pH, conductivity, dissolved oxygen, turbidity), nutrient levels (nitrate, nitrite, ammonia, phosphate), crayfish abundance, macroinvertebrate (BMI) communities, and *O. mykiss* stomach contents. Preliminary results indicate the effects of crayfish on nutrient levels are low or non-existent; however, the presence of crayfish seems to correlate with higher turbidity levels and lower BMI biodiversity. As we attempt to gain a better understanding of the effects of *P. clarkii* in the Topanga Creek ecosystem, we see value in future research efforts to examine steelhead trout growth and reproductive rates between reaches, crayfish diet, and post-removal recolonization.

## 66 MICRORNA-29 NEGATIVELY REGULATES EXPRESSION OF ONCOGENE TET2

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MicroRNAs are small, noncoding RNAs that post-transcriptionally regulate gene expression by binding directly to complementary sequences located within the 3′ UTRs of target mRNAs, thereby inhibiting their translation. Tet methylcytosine dioxygenase 2 (TET2), a gene frequently mutated in myeloid disorders, plays a key role in DNA methylation, a critical process in gene expression and cell differentiation. Mutations in TET2 are known to lead to aberrant changes in DNA methylation patterns that are strongly associated with leukemic transformation and hematopoietic malignancies. In this study, we identified 4 potential binding sites for miR-29 in the 3'UTR of TET2 using the TargetScan algorithm, indicating that miR-29 may directly regulate TET2 expression. By cloning the 3'UTR of TET2 containing these sites downstream of the firefly luciferase gene in the pMIR-REPORT reporter vector, the resultant plasmid was able to be co-transfected with a mimic of miR-29 or a scrambled miRNA control. Luciferase analysis then revealed that the miR-29 mimic was able to directly suppress reporter activity, and luminescence results showed a significant decrease when compared to the scrambled control. Therefore, our data indicate that miR-29 directly targets the oncogene TET2, and therefore it may play a role in regulating the development of hematopoietic malignancies. Further studies should confirm these results on the endogenous level.

## 67 SURFGRASS AS A SIGNIFICANT HABITAT: A COMPARISON TO URCHIN BARRENS

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Surfgrass (*Phyllospadix* spp.) is a type of seagrass predominantly found in the water of rocky shores and is credited for the establishment of a vast amount of healthy marine ecosystems. Communities of this seagrass occupy a widespread area in the Southern California Bight and other areas along the Pacific coast of North America. However, the overall surfgrass populations have been declining under the influences of urchin barrens and anthropogenic activities. Yet unlike the prioritized preservation given to kelp forests, which similarly are declining fast, attention given to the critical status of surfgrass seems much less. This might have been due to the high-energy waves of the water that surfgrass lives in. This unique habitat has created challenges for thorough research on surfgrass in its natural environment. The objective of this summer project was to raise more awareness for surfgrass and its ecological importance to the conference audience. To research its role in marine ecosystems, I compared the fish fauna in surfgrass to that in urchin barrens. I hypothesized that because of its vital ecological significance, surfgrass would provide healthier habitats and ecosystems than urchin barrens, especially in terms of fish abundance and density.

## 68 CHARACTERIZATION OF SEED PREDATION IN CASTOR BEAN (RICINUS COMMUNIS L.) PLANTS IN SOUTHERN CALIFORNIA

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The study characterizes the natural history of seed damage by an unidentified Lepidopteran larvae found inside of the pods and feeding on the seeds of Castor Bean (*Ricinus communis* L.) plants. Castor Bean plants are invasive in southern California, where approximately $82 million is spent annually to combat invasive plant species. Extremely toxic for many animals, Castor Bean plants produce seed crops throughout the year that do not form long-term seed banks. The unidentified Lepidopteran species may be a potentially useful biocontrol tool for reducing the standing seed crop future Castor Bean contributions to an ephemeral seed bank. Field collection of Castor Bean pods during the Spring months reflect three different levels of seed damage and an average of 6.2% ± 5.7% (mean ± SD) range of the standing seed crop with visible signs of damage. This study is currently analyzing the damage of the standing Castor Bean seed crop from the Fall months and is rearing seed pods in order to identify the Lepidopteran species. Initial observations indicate that there is less damage in the fall, relative to the spring. Further observations suggest that the seed damage occurs primarily to the seed elaiosome and secondarily impacts the seed coat. Additionally, presence of exuvia and frass suggest that the moths are emerging late summer or early fall.

## 69 EFFECT OF THE CAMARILLO SPRINGS FIRE ON TYTO ALBA (BARN OWL) DIET AND OCCUPANCY ACROSS CSU CHANNEL ISLANDS CAMPUS

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We investigated the effect of the May 2013 Camarillo Springs Fire on raptor diet. Within the fire's 9,809 hectares (24,238 acres) burn zone was the entire campus of California State University Channel Islands, home to our on-going exploration of *Tyto alba* (Barn Owl) population ecology. The Springs fire offered the unique opportunity to explore how *Tyto* diet changes in the immediate wake of such a complete burn event/ disturbance. Over the past three years we have collected and processed 203 owl pellets from known roosting sites bimonthly. Owl pellets were measured, weighed and disaggregated to evaluate the prey content through skull, jaw, or other hard structure identification. Prior to the 2013 fire, we had already documented variation in prey consumption across both seasons and roost position within the landscape. Post-fire, we observed a decrease in the diversity of the *Tyto* prey base and a precipitous decrease (87%) in occupancy/pellet production rate s. Nest and roost sites survived the fire, but impacts to prey availability appear to be inhibiting the recovery of raptors across our campus and surrounding lands. Seasonal variance of diet was analyzed for overall species richness and abundance of included prey species through an ANOVA test with season as the dependent variable. To explore effects of the Springs Fire on diet we compared the overall pellet weight, bone weight alone, prey abundance and prey richness within each pellet collected pre- and post-fire. The frequency of pellets found under any given roost site is an indicator of owl occupancy and use.

## 70 DISTRIBUTION AND GROWTH ESTIMATES OF YOUNG-OF-THE-YEAR GIANT SEA BASS, *STEREOLEPIS GIGAS*, OFF SOUTHERN CALIFORNIA

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Life history information on an ecologically, and once economically, important species such as the giant sea bass (*Stereolepis gigas*) is critical for the continued management of its fishery. Little is known about the life history of *S. gigas* due to the over exploitation of their fishery in the early 1900's, and depressed populations have prevented any detailed research. Legislation passed in the last 30 years have presumably helped the population begin its slow recovery, but still much remains unknown. The goal of this study is to fill in gaps in the early life history of the juvenile giant sea bass by 1) determining distribution and general ecology for the young-of-the-year of *S. gigas* in the wild, and 2) estimating their growth rates based on site aggregations and collections for otolith analysis. Spawning aggregations during the summer months yield a larval duration of approximately 30–60 days, after which settlement should start to occur. SCUBA transects with video and laser measurements will be used to estimate cohort populations and sizes in the field, and collections will allow otolith analysis for daily growth ring assessment. A better understanding of the growth rates will allow for more accurate estimates of future populations leading to better fisheries management policies, while distribution information can be used to protect important nursery areas. The early developmental process is crucial for completing the life history of this endangered species and this study is a key component of their life history as well as forms a baseline for other polyprionids.

## 71 CHANGES OF HYPERSPECTRAL REFLECTANCE AND PHOTOSYNTHESIS IN *AMBROSIA DUMOSA* FOLLOWING SUPPLEMENTAL NITROGEN ADDITIONS

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Anthropogenic nitrogen deposition has been increasing in the Mojave desert region due to downwind transport of urban and coastal nitrogen emissions. We examined the possibility of using soil nutrient concentration, photosynthetic gas-exchange and hyperspectral reflectance responses of *ambrosia dumosa* leaves as a proxy to determine if air pollution is resulting in unnatural fertilization of the Mojave region. Expected nitrogen deposition levels were administered to plants in both field and greenhouse studies. Using ground-based spectroscopy techniques and photosynthetic response curves, a number of metrics for plant physiological function were evaluated. From hyperspectral spectroscopy we determined that nutrient addition has resulted in physiological impacts, but not in the direction expected (i.e. control group showed overall "healthier" values that for fertilized plants). However, there was no significant difference of photosynthesis between control and fertilized groups, thus the changes in reflectance properties may be unrelated to photosynthesis. Further studies are needed to determine the functional significance of reflectance changes, but they nonetheless hold promise for use as proxies to identify alterations in natural soil nutrient concentrations within this human-impacted ecosystem.

## 72 CHARACTERIZATION OF SUGAR DIVERSITY IN FLORAL AND EXTRA FLORAL NECTAR FROM THE COASTAL CORAL TREE (*ERYTHRINA CAFFRA* THUNB.) IN SOUTHERN CALIFORNIA

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The Coastal Coral Tree (*Erythrina caffra* Thunb.) produces floral nectar (FN) that serves to attract pollinating insects, but also secretes nectar from extra-floral (EFN) glands that serves to attract predatory insects, such as ants. While studies on myrmecophytes (*i.e.* specialized plants that attract and interact with ants) have primarily focused on interspecific evaluations of EFN chemistry, the Coastal Coral tree offers an opportunity to contrast intraspecific nectar chemistry with differing evolutionary and ecological functions. We hypothesized that the richness of (molecular) sugar species, relative concentration, and diversity of sugars in FN and foliar EFN would diverge due to differences in the ecological role of the two types of nectar. High performance liquid chromatography with refractive index detection was used to identify the richness of sugar species (based on retention time), measure the relative concentration, and evaluate the diversity of sugars in FN and foliar EFN secretions. We detected sugar species unique to each gland type and report significant differences in the relative concentration of one sugar species common to both gland types. While the mean diversity index of sugars was similar for both gland types, the diversity of foliar EFN sugars was significantly more variable than that of FN sugars. The composition of FN showed little variation, and was reflective of its fundamental role in plant reproduction. Foliar EFN, however, demonstrated the variability expected of a context-dependent myrmecophyte that interacts with a facultative ant species assemblage across a mosaic of abiotic and biotic conditions.

## 73 AGE-BASED TRENDS IN HABITAT CHOICE IN HUMPBACK WHALE CALVES IN HAWAIIAN WATERS

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Humpback whales (*Megaptera novaeangliae*) of the Central North Pacific gather each winter on the Hawaiian breeding grounds. Within this area, female-calf pairs favor the Au'Au Channel between the Islands of Maui and Lanai, however to date, even though calf behavior varies significantly with calf age, there are no details available on how patterns of habitat use in female-calf pairs may vary as the calves' mature. In humpback whales, maternal size influences the size of the calf, therefore calf size does not indicate age. As an alternative, we use the furl of the dorsal fin as an indicator of relative calf age. In this study, surveys were conducted in the Au'Au Channel, and details of female-calf locations were collected, along with images of calf dorsal fins. Information on water depth, distance from shore and the nature of the terrain (bottom topography) was compiled for each location. The angle of the dorsal fin was measured and used to indicate the calf's relative age. Results indicated that while there was no significant difference in water depth and distance offshore according to calf age, there was pronounced variability in both depth preference and distance from shore in the more mature calves, compared to younger calves. There was also an indication that in general female-calf pairs prefer regions of rugged terrain. This information can be applied to improve habitat management practices to allow for the changes in calf behavior as calves mature during their time on the breeding grounds.

## 74 CALIFORNIA DOLPHIN ONLINE CATALOG

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Several research organizations studying bottlenose dolphins along the California coastline initiated a collaborative effort collectively titled the California Dolphin Online Catalog (CDOC). A priority action item was to produce an open-access, online database and photo-catalog, for California coastal bottlenose dolphins. Herein, we document some of the recent and notable Phase I milestones achieved through CDOC, including: collaborations among the CDOC research community, advancement of the CDOC database, publication of a CDOC-related journal article, creation of CDOC instructional videos, production of a CDOC PDF catalog for dolphins encountered off San Diego, and the presentation of several CDOC posters. Phase II of the CDOC program will work toward bringing the online catalog current through 2014, and incorporating data from all study sites. If the CDOC community can accomplish this task, the CDOC formatted OBIS-SEAMAP data-base would represent a 33-year time series of photo-identification and sighting data on coastal bottlenose dolphins throughout their range. The heuristic and interpretive value of a dataset such as this is tremendous; it provides the requisite information for management and conservation actions but also provides a unique opportunity to address novel research questions by way of range-wide collaborations.

## 75 PRODUCING ELECTRIC POWER FROM THE WIND: A STUDY OF WINDMILL BLADE FLOW MECHANICS

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Electric power generated from the wind can help our society become less dependent upon the production of foreign oil. Windmills of old were made with blades that had a cross-section of a rectangle. These were inexpensive blades sweeping out small circles by today's standards. Windmill rotor blades today have airfoil cross-sections which reduce drag and increase the performance. (Hansen, 2000) However, does a flat bottomed airfoil produce more power or the symmetrical airfoil? My hypothesis is that the symmetrical airfoils will outperform the others and the control blades. To test my hypothesis, I created a wind tunnel and wind mill to measure the different blades' power output. The blades were readily available from Flying Foam, Colorado Springs, Colorado, in both 2 and 5 inches from front to back. The length of the blade was 12 inches. The windmill was made out of PVC pipe. (Tymos, 2009) To smooth the airflow, I used an array of pre-cut pipes resembling the same used in a 2009 US DOE report. (US DOE, 2009) In each series of experiments, I waited for the wind tunnel and air smoother to reach a steady state flow of air. The airflow speed was 11.2 feet per second and 5.8 feet per second. I set the Static Angle of the blades on the rotor and then put the windmill into the airflow. I waited for the rotors to reach steady state and then recorded power data and measured the rotational speed of the rotor with a strobe light. I averaged the observations and graphed the output results. I calculated the net Dynamic Angle of attack for points along the leading edge of the rotors and graphed the ratio of the coefficients for each calculated net Dynamic Angle. My hypothesis was correct as the symmetrical airfoils out performed the flat-bottomed airfoils both when compared with each other and the control blades. At the 11.2 ft/sec wind speed, the 2″ symmetrical blade produced 28% more power than the 2″ flat-bottomed blade at a 5 degree static angle; 56% more power at a 10 degree static angle. The 2″ symmetrical blade also produced twice the power of the 5″ symmetrical blade.At the 5.8 ft/sec wind speed, the 2″ symmetrical blade produced 11% more power than the 2″ flat-bottomed blade at 5 degree static angle; 84% more power than the flat-bottomed blade at a 10 degree static angle. The 2″ symmetrical blade power output increased 12.5% at the 10 degree static angle over the 5 degree static angle. The 2″ blade produced 23% more power than the 5″ symmetrical blade at the 5.8 ft/sec wind speed.

## 76 THE EFFECTS OF URBAN POLLUTION ON THE REPRODUCTIVE PHYSIOLOGY OF CALIFORNIA HALIBUT (*PARALICHTHYS CALIFORNICUS*)

**M.M. Scanlon** and K.L. Forsgren. Department of Biological Sciences, California State University, Fullerton, CA, 92831

Anthropogenic influence on coastal ecosystems is increasing as our population grows. Urban pollution sources (e.g., runoff, wastewater effluent, gasoline leaks from boats) may contain compounds that affect fishes in a variety of ways. Endocrine disrupting compounds (EDCs) that mimic sex steroid hormones are of particular concern and have the potential to alter the reproductive physiology of teleost fishes.

California halibut (*Paralichthys californicus*) are a benthic, euryhaline fish that spends most of its adult life in the ocean. As juveniles, halibut inhabit more sheltered areas such as bays and estuaries that are more susceptible to anthropogenic influences. Of particular interest to this study are the EDCs from boat pollution and urban runoff. It is likely that harmful compounds from these sources settle in the sediment and influence juvenile halibut by direct contact and bioaccumulation via benthic food sources. Juvenile halibut were collected from three sites of differing anthropogenic-influence (i.e., Los Angeles Harbor, Newport Back Bay, Catalina Island) and their reproductive physiology was assessed by measuring blood sex steroid hormone levels and examining gonadal tissue histologically. It was hypothesized that halibut found in more pollution-heavy sites would have more indicators of reproductive dysfunction (altered steroid levels, unhealthy reproductive tissues) than fish collected in less influenced areas. Addressing this hypothesis will increase our understanding of how EDCs affect economically important fish species, such as halibut in southern California.

## 77 PROPOSAL OF PREDATOR-MEDIATED CONTROL OF THE CHAGAS VECTOR, TRIATOMA INFESTANS, WITH THE COMMON HOUSE GECKO

**N. Reyes** and V. Carmona-Galindo. Loyola Marymount University

Chagas disease is a fatal parasitic infection caused by *Trypanosoma Cruzi*. It plagues countries, predominately in the Americas, which have tropic climates and widespread poverty. The *T. Cruzi* parasite infects mammals, but matures into its transmittable stage within the small intestine of the *Triatoma Infestans* bug. Transference to humans occurs when the *T. Infestans* bug bites a person around the mouth for a blood meal, giving rise to its common name "kissing bug." The bug soon defecates after feeding, allowing the spread of the infectious parasite into the broken skin through the feces. The kissing bug is the main *T. Cruzi* vector that is responsible for the high incidence rates of Chagas Disease in poverty-struck, domestic areas. As a result, the main control-method for lowering disease prevalence in these regions is to eliminate the vector. Countries plagued by Chagas Disease are currently using harmful insecticides, with inadequate results, as their approach to exterminating the bugs. This study proposes a new control-schema that introduces a geographically invasive species of common house gecko, as a niche-predator, to control and decrease the *T. Infestans* survivorship. We propose that these geckos will consume the *T. Infestan* bug as prey, without the possibility of further transmission. The experimental association of ecological systems and vector control, in relation with human health, aim to expand the beneficial role of Biological Services in medicine. The study's purpose is to incorporate scientific research into infected bio phobic countries by the success of our proposed, alternative regulation-strategy for Chagas Disease.

## 78 CHANGES IN THE CHORION DUE TO FERTILIZATION AND EXTENDED INCUBATION IN THE CALIFORNIA GRUNION, *LEURESTHES TENUIS*

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Adult California grunion (*Leuresthes tenuis*) spawn on sandy beaches during spring high tides. The embryos develop within the sand enclosed in the chorion, which must be strong enough to protect the embryos but also allow hatching. This study examined biochemical and physical changes in the chorion of the California grunion before and after fertilization and after normal incubation [10 days post-fertilization (dpf)] and extended incubation (28 dpf). We measured crushing force with a force transducer and protein composition using sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). Although we expected crushing force to increase at fertilization due to the cortical granule reaction, mean crushing force was significantly greater in unfertilized chorions than in fertilized chorions. As predicted, mean crushing force was significantly greater in chorions at 10 dpf than at 28 dpf, which may make it easier for embryos to hatch after extended incubation when they are known to have less yolk. In solubilized chorions from unfertilized eggs at 10 dpf and 28 dpf, SDS-PAGE resolved five bands, which are similar in size to those found in chorions of other fish species. At 28 dpf, two additional, larger proteins were detected. Thus far, we have not been able to solubilize chorions of fertilized eggs for SDS-PAGE. Once we are able to solubilize them, we will correlate crushing force and protein composition to characterize the changes that occur in grunion chorions during embryonic development.

## 79 THE EFFECT OF LOW TIDE TEMPERATURE ON THE SUSCEPTIBILITY OF LIMPETS TO PREDATION

**R.J. Pound** and J.L. Burnaford. California State University Fullerton

Many studies have investigated the effects of temperature on ecothermic organisms on an individual level, but less is known about the effect of sublethal thermal stress on species interactions. This study addresses the question: how does low tide temperature affect an ectotherm's susceptibility to predation? Our study organisms are a common intertidal prey item (the owl limpet *Lottia gigantea*) and its low tide (the black oystercatcher *Haematopus bachmani*) and high tide (the sea star *Pisaster ochraceus*) predators. To address our question, we need information on the thermal conditions experienced by prey items in the field and the mechanism of predation by the predators. Because body temperature is closely linked to location during low tide for ectotherms, we started by quantifying prey distribution among microhabitats, which we predicted would have different thermal conditions. Preliminary results from Orange County rocky shores show that *L. gigantea* are unequally distributed among microhabitats, and future studies will quantify temperature differences between these locations. We used morphometric measurements on museum specimens of black oystercatchers to build a predator mimic for laboratory testing, and future studies will evaluate the effectiveness of our model. Changes in temperature as a consequence of global climate change may influence predator-prey interactions, which could alter community structure.

## 80 SPATIAL DISTRIBUTION, HABITAT SELECTION, AND EFFECTS OF TEMPERATURE ON ELASMOBRANCH SPECIES AT BIG FISHERMAN'S COVE, SANTA CATALINA ISLAND, CA

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Elasmobranchs are ectothermic, K-selected marine fishes, which makes them vulnerable to overfishing, so understanding how they evaluate and select habitats becomes essential for protecting these species from over exploitation. Distribution of three elasmobranch species found in Big Fisherman's Cove, Santa Catalina Island (*Myliobatis californica*, *Rhinobatos productus*, and *Urobatis halleri*) was used to determine habitat selection based on field observations and water temperature mapping. Elasmobranch distribution and habitat data were analyzed using ArcGIS. Between the areas used by each of the three species there was a 7% overlap, demonstrating there could be similar habitat preferences. All species were found primarily associated with two of the possible substrata types, sand and vegetation ($p<0.001$). Throughout the surveys, a wide range of temperatures occurred in all present habitat types; however, there was a significant peak in distribution around water temperatures of 18°C ($p<0.001$). The benefit of this data is that better predictions could be made on where to find elasmobranchs of each species based on substrata type and temperature.

## 81 THE EFFECTS OF ENDOCRINE DISRUPTING COMPOUNDS ON ATLANTIC STURGEON REPRODUCTIVE PHYSIOLOGY

**J. Cabrera**, S. McCormmick, and K.L. Forsgren. Department of Biological Science, California State University Fullerton 92834

During early maturation, juvenile Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) were exposed to endocrine disrupting compounds (EDCs) to observe the effects on sexual differentiation and gonad development. Juvenile fish were exposed to varying concentrations of nonylphenol, 17β-estradiol (E2) and 17α-ethinylestradiol (EE2) to determine the degree of gonadal development. Ovaries and testes were dissected from 88-110 day-old fish and were processed for paraffin histology. 5 μm tissue sections were examined using a light microscope. Sturgeon 90 days of age and younger had undifferentiated gonads with no distinguishing characteristics of ovarian or testicular development. At 109 and 110 day-old sturgeon, developing testicular tissue was observed and included the presence of seminiferous tubules and vas deferens. Clustered ovarian cells beneath the gonadal epithelium layer indicating a differentiated female juvenile were also observed in 109 and 110 day -old fish. Overall, the current study suggests that EDCs may influence sexual differentiation and gonad development in juvenile Atlantic Sturgeon.

## 82 DETERMINING AND PROFILING THE PREVELENCE OF ANTIBIOTICS –RESISTANT BACTERIA (ARBs) IN THE WATERS OF THE BALLONA WATERSHED

**D. Pham**[1] and A. Lee[2]. [1]1425 Via Arco, Palos Verdes Estates, CA 90274. [2]5403 Littlebow Rd., Rancho Palos Verdes, CA 90275. Mentor: John Dorsey, Environmental Science Professor, 1 LMU Dr., Los Angeles, CA 90045

The overuse of antibiotics has led to the rise of antibiotics-resistant microbes in the environment. Recently, a prevalence of bacterial strains with insensitivities some types of antibiotics have been found in the Ballona Wetlands. This investigation addressed the Ballona Wetland's effectiveness in reducing these bacterial counts. Ebb/flood tide, and sediment samples were collected and the bacteria was extracted from the samples and plated. A standard replication method was then used to replicate colony growth and the tryptic soy agar plates were then infused with antibiotics. Photos of replica plates were taken and were analyzed and colonies were identified. Then, the bacteria were tested to determine the presence of ABIs using the Kirby-Bauer method. Cumulative frequencies of ABIs of flood, ebb, and sediment samples were compared using the Kolmogorov–Smirnov test. If the wetlands were functioning properly, bacterial counts would be reduced during ebb tide and that there would be a significant difference between the ebb and flow tide samples, however they were nearly identical. It was also expected that the cumulative frequency of ABIs found in sediment would have a very different trend, yet the trends were very similar to ebb and flood. The existence of bacteria resistant to a wide spectrum of antibiotics in the Ballona Wetlands has been confirmed. Additionally, the patterns of frequencies of ABIs occurring have been consistent. As this research is ongoing, the next steps will involve DNA sequencing of the bacteria and identifying the species of prevalent bacteria.

## 83 REDUCING CARBON FOOTPRINT THROUGH INTEGRATION OF LED STREETLIGHTS

**A. Wei** and D. Sonner. Walnut High School, 400 N. Pierre Road, Walnut, CA. 91789

Cities throughout the world are still using incandescent and compact fluorescent bulbs for their street lights, unaware of how detrimental they are to the environment and economy. The hypothesis was that although the wattage and lumen output is less amongst the light-emitting diode, or LEDs, it provides a wider spectrum of colors, allowing for less wattage usage and lumen output, but will still provide a similar result relating to the general brightness and color output, if not better, than those of Compact Florescent Lights (CFLs) and incandescent bulbs. My goal and mission is to educate the public and city on the implementation of LEDs into city street lights. This phasing in of LEDs will reduce energy consumption, reduce the chance of mercury poisoning among civilians and surrounding landscapes, reduce the amount of mercury that is released into the air through the burning of coal, and increase the environmental benefits. Subjective testing was done using a 23W CFL, a 60W incandescent, a 9W LED, and a 20W LED, comparing the general brightness and color output of the bulbs when shown to a general audience. The audience were not told the wattages of the bulbs prior to the experiment to avoid skewing the data. A positive relationship was found between the usage of less wattage and general brightness and color output.

## 84 EMERSION AND TEMPERATURE EFFECTS ON GROWTH RATES AND BYSSAL THREAD PRODUCTION IN TWO SYMPATRIC MARINE MUSSEL SPECIES

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Marine mussels are exposed to various stressors on a daily basis; the most prominent of these stressors is their exposure to tidal variation. In order to better understand the effects of tidal variation, we exposed mussels to daily four-hour intervals in one of three treatments: heat, air, or seawater control. The trials were run on two species: *Mytilus californianus*, a species native to California, and *M. galloprovinicalis*, an invasive species thought to maintain high growth rates even under stressful conditions. Our research aims to answer the following questions regarding these two sympatric species: 1) Does recurring stress impact growth rates? 2) Does pre-acclimation to aerial exposure influence survival and/or growth of mussels that are then exposed to

extreme high temperatures in air? 3) Are there tradeoffs between growth in body mass and growth of byssal threads, the protein-rich extensions used to anchor individuals to the rock? 4) Do any of these responses vary between the native and the invasive species? We predicted that growth rates of individual mussels will be negatively impacted by recurring stress, and that there are probably trade-offs in body mass and byssal thread production. Overall, our results indicated that acclimation to recurring stress of emersion did not significantly impact growth rates or survival of either mussel species, either before or after being exposed to three days of extreme high temperatures (32°C). In *M. galloprovincialis*, there was a divergent temporal pattern of byssal thread production between mussels exposed to warm air and mussels held in seawater.

# SATURDAY ABSTRACTS IN PROGRAM ORDER

## 85 THE AMERICAN CETACEAN SOCIETY: EDUATION, CONSERVATION, AND RESEARCH – THEY'RE NOT SAVED YET!

**D. Alps**[1,2]. [1]American Cetacean Society-Los Angeles Chapter, San Pedro, CA 90733 [2]Cabrillo Marine Aquarium, San Pedro, CA 90731

The American Cetacean Society is the world's oldest whale conservation organization. Launched in 1967, its mission is to protect whales, dolphins, porpoises, and their habitats through public education, research grants, and conservation actions. ACS hosts a biennial conference and publishes an annual journal to further this mission, both of which are tools to bridge the gap between the scientific community and the general public. The organization also consists of eight chapters, the largest of which is the Los Angeles Chapter. The programs of the Los Angeles Chapter directly engage thousands of people each year in the ACS mission of education, conservation and research. "Cabrillo Whalewatch" is a very successful whale watch naturalist program, enlisting over 100 people each year. The ACS-LA Gray Whale Census and Behavior Project is the longest running citizen science project of its kind, utilizing volunteers to monitor the gray whale migration from a shore-based location during all daylight hours of a six month spam. The newest program, WhaleSAFE, seeks to raise awareness of safe whale watching practices with personal watercraft, private boaters and commercial whale watch companies. These programs all rely heavily on their many dedicated volunteers, as well as the collaborative efforts of partnering researchers, institutions and educators.

## 86 BLUE WHALE EARPLUG REVEALS LIFETIME CONTAMINANT EXPOSURE AND HORMONE PROFILES

**M. Berman-Kowalewski**, S.J. Trumble, E.M. Robinson, C.W. Potter, and S. Usenko. 2559 Puesta del Sol, Santa Barbara, CA 93105

Lifetime contaminant and hormonal profiles have been reconstructed for an individual male blue whale (*Balaenoptera musculus*, Linnaeus 1758) using the earplug as a natural aging matrix that is also capable of archiving and preserving lipophilic compounds. These unprecedented lifetime profiles (i.e., birth to death) were reconstructed with a 6-mo resolution for a wide range of analytes including cortisol (stress hormone), testosterone (developmental hormone), organic contaminants (e.g., pesticides and flame retardants), and mercury. Cortisol lifetime profiles revealed a doubling of cortisol levels over baseline. Testosterone profiles suggest this male blue whale reached sexual maturity at approximately 10 y of age, which corresponds well with and improves on previous estimates. Early periods of the reconstructed contaminant profiles for pesticides (such as dichlorodiphenyltrichloroethanes and chlordanes), polychlorinated biphenyls, and polybrominated dipheny l ethers demonstrate significant maternal transfer occurred at 0–12 mo. The total lifetime organic contaminant burden measured between the earplug (sum of contaminants in laminae layers) and blubber samples from the same organism were similar. Total mercury profiles revealed reduced maternal transfer and two distinct pulse events compared with organic contaminants. The use of a whale earplug to reconstruct lifetime chemical profiles will allow for a more comprehensive examination of stress, development, and contaminant exposure, as well as improve the assessment of contaminant use/emission, environmental noise, ship traffic, and climate change on these important marine sentinels.

## 87 THE CALIFORNIA DOLPHIN ONLINE CATALOG: COLLABORATION, COLLABORATION, COLLABORATION!

**R.H. Defran**. Cetacean Behavior Laboratory, San Diego State University, 11060 Delphinus Way, San Diego, CA 92126

The bottlenose dolphin (*Tursiops truncatus*) is the most common cetacean in the coastal waters off California. Within their over 1,000 km-long distribution, these dolphins exhibit extensive back-and-forth coastal movements and demonstrate little site fidelity to any one area. The California Dolphin Online Catalog (CDOC), initiated in 2011, is an internet-based 30 yr. archive of dolphin dorsal fin photo-identification and sighting data collected from individuals within this population. Accessibility to the CDOC facilitates collaborations among researchers at differing locations along the California and Baja coastline. The value, and often the necessity, of such collaborations is illustrated by two case studies which draw on data collected by a number of research laboratories in 1981–1989 and in 1996–2001. In both cases, photo-identification catalogs from study areas in Ensenada (Baja California), San Diego, Orange County, Santa Monica Bay, Santa Barbara, Monterey Bay and San Francisco Bay exhibited a high proportion of inter-area photographic matches, which established the range and movement patterns of dolphins in this population. Further, these collaborations confirmed the continued northern range extension of this population from southern California (Los Angeles) to San Francisco Bay.

## 88 FOOD FOR THOUGHT: INFLUENCE OF THE "PREY-SCAPE" ON GRAY WHALES OF CLAYOQUOT SOUND, BRITISH COLUMBIA

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Since 1983 the University of Victoria (UVIC) Whale Research Lab has been studying gray whales in Clayoquot Sound, British Columbia. A project that began by studying the affects of the increasingly popular Tofino whale-watching industry on the whales, the focus soon switched to the importance of the relationship between the whales and their habitat and the dynamics of the predator prey relationships. Here, unlike other "primary" feeding areas for gray whales, the food source is a swarming species of tiny shrimp called mysids. Here, the link between the prey, mysids, and the predator, gray whales is intricately tied. The importance of both the bottom-up and top-down predator-prey relationship is key, with mysids in the middle influenced by both. Here, the ecosystem-approach to understanding the whales is essential, as you cannot begin to understand the biology, ecology, or behavior of the whales without a first understanding their relationship to their tiny food, source. This presentation will cover two decades of research on gray whales done by the UVic WhaleLab, and some of the more outstanding results that have come from that work.

## 89 BEHAVIORS OF SOUTHERN CALIFORNIA CETACEANS: OBSERVATIONS FROM A SMALL AIRCRAFT 2008–2013

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Small aircraft enable a "bird's eye" view of marine mammal behavior at/near the water surface. During 2008–2013, we flew 87,734 km of line transect and "focal follow" aerial survey effort in the Southern California Bight to systematically collect data on 2,707 sightings of ~222,457 individual cetaceans representing 19 species, funded by the U.S. Navy Pacific Fleet. Focal follows involved circling a cetacean group for 5–60+ minutes and taking high-definition (HD) video and photos to document behavior primarily of blue, fin, gray, humpback, sperm, minke and killer whales; and Risso's, common bottlenose, short-beaked and long-beaked common, and northern right whale dolphins. HD media allow photo-identification of individuals and species confirmation from altitudes of 1,000–1,500 feet. The "bird's eye" perspective facilitates descriptive and quantitative analyses of

behavior previously little described for typically offshore species: whale calf nursing/back-riding, group cohesion, social affinity/composition, group shape and dimension "envelope", cues leading to group behavior changes, mixed species interactions, individual whale respiration/dive rates, etc. Behavior differs significantly by species, calf presence, time of day, time of year, subregion, water depth, slope, distance from shore, and presence of other species. For example, Risso's dolphins were 13 times more likely to rest than common dolphins, and dolphin group size increased significantly with calf presence. As species body size decreases, group size increases and individuals decrease distance between neighbors. We hypothesize that inter-specific differences of spacing and behavior are related to predation pressure, food resources, and communication capabilities/needs that lead to occupation of different niches within the same ecosystem.

## 90 RESOURCE SELECTION FUNCTION ANALYSES: ASSESSING HABITAT USE RELATIVE TO BEHAVIOR AND RESOURCE CHARACTERISTICS/AVAILABILITY FOR FIVE COMMON MARINE MAMMAL SPECIES IN THE SOUTHERN CALIFORNIA BIGHT

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In 2008–2012, fifteen aerial surveys of systematic line-transects were conducted off Southern California to obtain baseline data on occurrence, distribution, density, abundance and behavior of marine mammals (MM). Site characteristics at MM locations were analyzed by estimating Resource Selection Functions (RSF) to quantify and describe baseline habitat use as a precursor to assessing potential changes in these patterns relative to anthropogenic activities, including U.S. Navy training exercises. For RSF analyses, habitat characteristics at MM locations were contrasted to characteristics at 35,167 randomly selected "available" locations in the study area. RSFs were estimated via the use-availability approach and predicted probability of species occurrence at all locations in the study area as a function of seven covariate habitat variables. Models (n = 60 fin and 40 gray whale groups, 135 Risso's and 31 bottlenose dolphin groups, 157 California sea lion groups) were fit for three behavior states (mill, rest/slow travel, medium/fast travel) and combined to document behavior/habitat associations. Species differed significantly in habitat use and corresponding habitat associations based on behavior. Medium-fast traveling fin whales were associated with deep water over flat basins/plateaus ($p=0.0017$). Fin whales also preferred the San Nicolas Basin ($p=0.0517$). Risso's dolphins rested/slow traveled more in deep vs. shallow water ($p=0.0803$). Overall, resulting habitat-use patterns demonstrate fast movement across basins and rest/slow travel over ridges where upwelling is most likely to occur. The RSF approach quantitatively demonstrates the importance of considering behavior and social context in habitat selection and use.

## 91 A HITCHHIKER'S GUIDE TO THE SOUTHERN CALIFORNIA BIGHT; ARE SIGHTINGS OF XENOBALANUS GLOBICIPITIS ON THE RISE?

**B. Alps**. Cabrillo Marine Aquarium, San Pedro, CA 90731

The pseudostalked barnacle *Xenobalanus globicipitis* is a cosmopolitan species and an obligate phoretic commensal that attaches itself to cetacean hosts. The species' distribution includes all of the world's oceans with a latitudinal range from polar regions to the tropics and 34 documented host species range in size from the blue whale (*Balaenoptera musculus*) to the vaquita (*Phocoena sinus*). An increase in colonization by *X. globicipitis* could be an important indicator of population health as susceptibility has been linked to immune system impairment. Anecdotal observations indicate a dramatic increase in sightings of *X. globicipitis* on several cetacean species in the Southern California Bight. Sets of photos of long- beaked common dolphins (*Delphinus capensis*) obtained opportunistically in the Santa Barbara Channel, San Pedro Channel, and Santa Monica Bay are analyzed and used to compare prevalence of *X. globicipitis* in the calendar years 2011 and 2013.

## 92 SPOTTER PRO: A CITIZEN SCIENCE AND TECHNOLOGY TOOL TO SUPPORT MARINE MAMMAL OBSERVATIONS OFF THE COAST OF CALIFORNIA

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Protecting endangered whales is a shared priority across both public and private sectors alike. Endangered blue, fin and humpback whales feed within West Coast National Marine Sanctuaries and large commercial vessels also transit these waters en route to and from the busiest U.S. ports. The co-occurrence of whales and ships creates an elevated risk of vessel strike, and mortality to whales. To address this issue a joint sanctuary working group, including representatives from conservation groups, the shipping industry, and the scientific community from around the US submitted a series of recommendations to sanctuaries. A key recommendation was to coordinate a volunteer sighting network, composed of the whale watching community, naturalists, recreational boaters, fishing community and large commercial users, and to supply that network with the necessary mobile technology to make the sighting collection effort as seamless and error free as possible. Titled "SpotterPro," the application (and associated database) engages and leverages the numerous users that are in West Coast waters to crowd source information on the distribution of whales and increasing public awareness of national marine sanctuaries. The data from an engaged community informs our understanding on the distribution of whales within sanctuaries. It also allows users of sanctuary waters to help protect these amazing and endangered whales by serving as citizen scientists and informing management decisions such as a Dynamic Management Area that requests vessels to slow down or reroute around concentrations of whales.

## 93 MARINE MAMMAL REAL-TIME MULTI-PLATFORM TRACKING, MAPPING DATA SHARING AND POST-PROCESSING

**D. Steckler**, M.A. Smultea and C.E. Bacon. PO Box 256 Preston, WA 98050

Technological advances through development of integrated software for marine mammal (and other marine/terrestrial) observations have enhanced ease, accuracy, efficiency, and decreased cost of data collection and processing. Mysticetus Observation Software (MOS) was developed to meet the needs of marine mammal biologists for user-friendly, user-configurable software to collect and display sighting and environmental data in real-time, and produce summary analyses and reports relative to imported environmental data. Users can view sighting and study effort data in real-time relative to bathymetry, other platforms and potential anthropogenic disturbances, geographic references, distances to selected parameters, etc. Examples include simultaneous real-time display and tracking of (1) visual sightings and behavior with acoustic cetacean detections from a small plane deploying sonobuoys, and (2) sighting locations relative to sound mitigation distances regulate d by the National Marine Fisheries Service (NMFS) for potential disturbances such as seismic and sonar vessel sounds and other nearby vessels and sightings. Data can be viewed across multiple platforms (e.g., vessels, aircraft, land including inland offices) via internet and satellite links as well as uploaded for secure storage and backup. Such technology also has significantly reduced post-processing time and costs by summarizing effort, sightings, species, etc. in tables, and displaying graphs with user-friendly instructions. Other related recent technological advances include using MOS to display and track views and locations from a small unmanned aerial vehicle equipped with a high resolution camera to track and view marine mammals in real-time via internet/satellite.

## 94 WHALE STORIES: CONNECTING THE PUBLIC TO DATA

**K. Mathes**. Aquarium of the Pacific, 100 Aquarium Way, Long Beach, CA 90680

Informal science institutions such as aquariums have important roles to play in communicating current science, particularly in keeping people excited about scientific exploration and discovery—science as a process. Here we present a model for connecting the public to current cetacean research. For the past four years, a strategic partnership with researchers at the Cascadia Research Collective (CRC) has given the Aquarium of the Pacific the opportunity to train staff to collect photo identification data on whales during public whale watching trips. The main initiative of this research is to collect photos of blue, fin, and humpback whale dorsal fins and fluke fins to match with previously documented photos from CRC. Data on additional cetaceans are also collected. Data on sightings provide critical information about the behaviors of these whales in correlation

with the shipping traffic in this area. The second phase of this project will allow the public to further engage with data collected on whale watching trips. Our highly trained staff interprets these findings and their experiences to our general audience both through boat programs and on-the-floor interpretation. An interactive platform created by the Aquarium of the Pacific helps connect the stories of the whales that are sighted in our area to the urban ocean, and how humans and marine life both utilize our local waters to thrive.

## 95 WHALE MAPP: CITIZEN SCIENTISTS CONTRIBUTE AND MAP MARINE MAMMAL SIGHTINGS

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Traditional methods of gathering the data needed to map marine mammal distributions and assess human impacts on their populations require extensive time and resources. To reduce the burden associated with collecting and managing marine mammal observations, a geographic information system (GIS) solution was developed using a volunteered geographic information (VGI) approach. Whale mAPP is a system of mobile and web applications that provide easy access for the public to submit marine mammal observations and visualize the results on maps. A mobile application utilizes GPS enabled smart phones to record sightings, automatically track boat path to provide data on effort, and collect photographs which are then transmitted to an online geodatabase that is accessible to researchers and the public. The web application provides users with the ability to query the observations by region, date, and time, visualize sightings directly, and download data in shapefile format. Educational materials on the website include basic biological information on each marine mammal species along with images and illustrations of identification features. To help encourage conservation efforts, threats to marine mammals are discussed and research efforts highlighted with brief stories, interviews, and videos. Curricular materials with conservation themes are designed for middle school students and utilize ESRI ArcGIS Online software to provide experience with applying the scientific method and helping to improve spatial literacy. The additional data collected by this tool will help supplement the knowledge of marine mammals to aid in research and management efforts.

## 96 THE ISOLATION OF INDIVIDUAL BONE OSTEOCYTES FROM A TRICERATOPS HORN AND NOTES ON THEIR PRESERVATION

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We previously reported on soft fibrillar bone tissues extracted from a Triceratops horridus supraorbital horn collected at Hell Creek Formation in MT (SCAS Annual Meeting, Long Beach 2013). Hand sized pieces of horncore material were decalcified and yielded numerous soft bone osteocytes (see figures). Osteocytes were soft and pliable and featured extensive filipodia which tapered to 300 nm widths in some instances with extensive branching. Dialysis of aliquots containing soft material in pure water allowed for handling and isolation of individual washed cells for fixation and further examination. Organelle-like microstructures were observed in many cells. Fluorescent staining of specimens provided positive confirmation an abundance of plant roots and fungal hyphae transecting the horn. Picrosirius staining for collagen yielded inconclusive results. Initial UV fluorescent tests are promising for the presence of autogenous proteins. In contrast to deeply sequestered soft tissues recovered from dinosaur femur fossils, it is unclear why remarkable ultrastructural preservation exists in these tissues in the presence of plant and microbial activity, autolysis, hydrolysis, wide temperature variation and the fact that the highly vascular bone was open to the influence of soil matrix.

## 97 EARLY EVOLUTION, DIVERSIFICATION, AND GEOGRAPHIC DISTRIBUTION OF THE SUBORDERS CONSTITUTING THE MAMMALIAN ORDER ARTIODACTYLA

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Artiodactyla comprises three extant suborders and perhaps five unnamed extinct ones.

1 (basalmost artiodactyls [paraphyletic]: diacodexid, primitive [unassigned, some dichobunine] dichobunid dichobunoids): M1–3 (Ms) bunodont, triangular; metaconule unenlarged; no hypocone (Old World [OW] origin).

2 (some more-derived dichobunines plus lantianiine, some eurodexine dichobunids): Ms quadrate, incipiently selenodont; hypocone distinct; metaconule in latter two groups still connected to protocone by postprotocrista, interrupting transverse valley (TV) (OW).

3 (most-derived dichobunoids [dichobunine *Dichobune*, hyperdichobunine dichobunids; might include other dichobunids with quadrate hypoconiferous Ms] plus caenotheriids): Ms relatively selenodont, quadrate; tritubercular distal lobe with distinct metacone, metaconule, and hypocone; TV continuous; paraconule reduced/lost (OW).

4 (entelodontids): Ms bunodont, quadrate, with tritubercular distal lobes, uninterrupted TVs, but paraconules unreduced (OW origin).

Bunodonta/Suiformes (raoellids, cebochoerids, choeropotamids [inc. haplobunodontids], palaeochoerids, sanitheriids, suids, tayassuids, hippopotamids, anthracotheriids, anoplotheriids [inc. dacrytheriids], mixtotheriids, dichodontids, xiphodontids, amphimerycids, maybe some dichobunines): Ms primitively bunodont, quadrate, each with bitubercular distal lobe bearing enlarged metaconule as distolingual cusp. (OW origin, except tayassuids).

Primitively, those suborders lack coossified hind-limb elements.

Tylopoda (oromerycids, camelids, oreodontoids, protoceratids): Ms primitively bunoselenodont, quadrate, each with mesostyle plus bitubercular distal lobe bearing enlarged metaconule as distolingual cusp; ectomesocuneiform (North American origin).

5 (*Diacodexis secans*, *D. minutus*, leptochoerids, helohyids [inc. achaenodontids], homacodontids, bunomerycids, hypertragulids [inc. *Simimeryx*, *Parvitragulus*, hypisodontids]): Ms primitively bunodont; tibia, fibula coossified distally; ectomesocuneiform (North America).

Pecora/Ruminantia (*Limeryx*, *Asiohomacodon*, praetragulids, archaeomerycids, lophiomerycids, leptomerycids, tragulids, "pecorans"): Ms primitively bunoselenodont, but (unlike hypertragulids) with mesostyles; tibia, fibula primitively unfused or coossified proximally; cubonavicular; primitively, no ectomesocuneiform (OW origin, except leptomerycids).

## 98 USING NATURAL HISTORY MUSEUM COLLECTIONS TO BETTER UNDERSTAND THE GENETIC DIVERSITY OF ENDANGERED FAIRY SHRIMP (CRUSTACEA: BRANCHIOPODA: ANOSTRACA)

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Since 2011 the Natural History Museum of Los Angeles County (NHM) and the United States Fish and Wildlife Service (USFWS) have worked closely together to modernize the guidelines governing how voucher specimens of the two California federally-listed fairy shrimp species, *Branchinecta sandiegonensis* and *Branchinecta lynchi* (Crustacea: Branchiopoda) are preserved and how voucher metadata is databased. All new voucher specimens are preserved in pure 95% ethanol (none denatured ethanol), and are immediately electronically databased upon being accepted for accessioning into NHM's Crustacea collection. As well as the new material that is being preserved in pure 95% ethanol. Over the past few years all historical anostracan collections at NHM have been databased and screened for their utility in molecular studies. This new material makes it feasible to use only museum collections to answer very basic questions about local fairy shrimp genetic diversity: interspecific relations across the state of California and intraspecific relationships within populations. Our analyses are starting with data from PCR amplifications for mitochondrial and nuclear genes. We are focusing on COI in our analysis to take advantage of the large amount of sequence data already available on GenBank for our taxa of interest.

## 99 UNCOVERING THE GENOMIC BASIS OF DROSOPHILA MELANOGASTER RESISTANCE TO FUNGAL PARASITES

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It is well known that various environmental stresses can affect natural selection on a population. As a result, natural variation will occur within that population, giving certain organisms a competitive edge upon selective pressure. Previous research has shown that Drosophila melanogaster populations derived from tropical climates exhibit higher resistance patterns than those derived from temperate climates when exposed to the selective pressure of *Beauveria bassiana* parasitism. However, the genetic basis and molecular mechanisms that confer these differences in resistance remains unknown. In order to define the underlying cause of these differing phenotypic responses, we exposed over 30 D. melanogaster inbred lines to *B. bassiana* and tracked their survival over a 28-day period. We found that indeed tropical-derived populations were more resistant to *B. bassiana* than temperate-derived populations, and that there exists a genotype effect on resistance levels. Subsequently, by comparing the genomes of the most and least resistant lines, we hope to uncover specific genomic sequences that may be associated with the observed differences in phenotypic response to parasitism. Once the genetic basis is defined, we will then be able to elucidate the molecular mechanisms and biochemical pathways from which an insect's competitive edge in *B. bassiana* defense may arise.

### 100 MOLECULAR ANALYSIS OF LOCAL AND GLOBAL *DOHRNIPHORA CORNUTA* (INSECTA: DIPTERA)

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A 2013 paper by Hash et al, suggests that *D. cornuta* is an introduced phorid species that falls within the same clade as Old World species. This research aims to analyze the genetic diversity of local and global *Dohrniphora cornuta* (Diptera: Phoridae) using molecular and morphological techniques. Local specimens are taken from BioSCAN, a survey of insect biodiversity in the Los Angeles area conducted by the Natural History Museum of Los Angeles County. 30 Malaise traps equipped with microclimate weather stations capture and preserve specimens in 95% ethanol and provide information about the local weather conditions where each specimen is collected. Global specimens to be analyzed are taken from various locations around the world. We have already amplified the 16S gene using standard extraction and PCR techniques. We plan on adding more mitochondrial genes to look at genetic diversity within *D. cornuta*. We also plan to look for morphological variation between populations of *D. cornuta*.

### 101 WOLBACHIA INFECTION RATES IN LOS ANGELES BASIN HUMPED-BACK FLIES (INSECTA: DIPTERA: PHORIDAE)

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Phorid flies, commonly known as humped-back flies, are a hyperdiverse family of the Diptera that are prevalent in the Los Angeles basin. Phorids are obtained from the BioSCAN project, a large-scale urban biodiversity survey conducted by the Natural History Museum of Los Angeles. This unprecedented collection of insects was used to screen phorid flies for *Wolbachia* infection, using PCR assays and Sanger sequencing. *Wolbachia* is a genus of alpha-Proteobacteria that is one the most widespread reproductive parasites in the world and has the ability to proliferate genetic modifications in its hosts. Screening of the phorid *Megaselia sulphurizona* of the Los Angeles basin during fall of 2013 established that about 21% of the individuals were infected. Current research concentrates on *Megaselia scalaris*. We are now screening various genetic lines of *M. scalaris* for *Wolbachia* infection using PCR analysis, and specifically focusing on the wsp gene (*Wolbachia*-specific primer). Because *Wolbachia* has unique mechanisms to influence host reproductive capability and sex ratios, we plan on comparing sex ratios for infected vs. uninfected lines.

### 102 WHEN AFRICAN CLAWED FROGS INVADE: INDIRECT INTERACTIONS BETWEEN NATIVE AND INVASIVE AMPHIBIANS

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The African clawed frog (*Xenopus laevis*) has established invasive populations outside of its natural range, including throughout southern California; however, little is known concerning its impacts on native ecosystems. My work explores the effects of African clawed frogs and their potential to cause indirect behavioral responses in native California amphibian species. Pacific treefrog (*Pseudacris regilla*) larvae and adults are known to respond to the presence of potential predators by reducing foraging activities and spatial avoidance, respectively; however, it is not certain California amphibian species will perceive the novel African clawed frog as a potential predator. I performed lab- and field-based experiments to determine if larval and adult Pacific treefrogs will exhibit these behaviors in response to the presence of adult African clawed frogs and found that both adult and larval stages respond. Larval Pacific treefrogs significantly reduced their activity levels when in the presence of an African clawed frog. In addition, adult Pacific treefrogs actively avoided the side of enclosures that harbored an African clawed frog. These findings suggest that California amphibians may benefit from innate predator avoidance response in areas where the African clawed frog has invaded but further research exploring the predation rates and disease transmission potential of the clawed frog is necessary to more fully evaluate the potential impacts of this invasive species on native amphibians.

## 103 LET'S TAKE A WALK IN THE WOODS AND THROUGH THE "TREES" IN BENTHIC ASSEMBLAGES ON SOFT SEDIMENTS

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In most ecosystems, observed or potential impacts of development activities are described in terms of effects on large, long-lived organisms (the "trees") that characterize the biological assemblages and long-term conditions under consideration. Moreover, projected recovery trajectories are typically based on population structure and longevity of extant longer-lived members of assemblages. Thus, early infaunal ecologists employed approaches similar to those developed by plant ecologists. They based their descriptions of ecosystem values for assemblages inhabiting soft sediments, or impacts to these systems, on the "trees". However, in recent decades, the approach applied for soft sediments has based descriptions, decisions, and projections of effects and recovery trajectories on "weeds", the tiny, abundant, ephemeral, disturbance-oriented organisms living in the sediments. Consequently, long-term effects of many development-related activities affecting these assemblages have been severely underestimated. Moreover, predicted recovery rates, again based on "weeds", have been far shorter than in reality. Consequently, this approach has likely produced flawed evaluations for effects and recovery times resulting from many anthropogenic activities. An alternative hypothesis evaluated here is that "trees" in nearshore assemblages on the Hueneme Shelf produce a more realistic assessment of conditions and recovery times than "weeds". Factors compared include species composition, habitat specificity, life span, and estimates for biomass and contributions to secondary production through sublethal predation. I argue that combining classical approaches with new technologies would achieve more realistic insights into effects and recovery trajectories. Furthermore, it is likely that combined approaches would: 1) be more cost-effective; and 2) produce results more rapidly.

## 104 THE GENETIC DIVERSITY AND POPULATION STRUCTURE OF BARRED SAND BASS (*PARALABRAX NEBULIFER*)

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Barred sand bass (commonly, sand bass), *Paralabrax nebulifer*, is part of the largest recreational fishery in Southern California as well as a large artisanal fishery in Mexico. This species ranges from Santa Cruz, California to the southern tip of Baja California, Mexico, but is common only south of Pt. Conception. Sand bass form large spawning aggregation in the summer months of June-August, which makes them highly susceptible to overfishing. In the last decade, populations of sand bass in southern California have experienced a severe decline in numbers and subsequently the recreational fishery has been seriously impacted. Large population declines, such as a fishery decline, can lead to a decrease in genetic diversity and potentially a genetic bottleneck. This is a concern for barred sand bass populations, however the population structure and genetic diversity of barred sand bass populations was previously unknown. This study looks at both aspects using the d-loop region of the mitochondrial DNA and microsatellite markers

for populations throughout California and Mexico. Both markers show a high degree of genetic diversity and suggest two populations of barred sand bass however there is a high degree of connectivity between those populations.

### 105 STOCK ENHANCEMENT STRATEGIES FOR GREEN ABALONE: *HALIOTIS FULGENS*

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Abalone are being exploited around the globe and efforts to restock them have been ongoing for several decades. Stock enhancement has not been widely successful. This is thought to be related to the size of the outplanted animals and difficulties tracking them. Similarly, in Southern California, there have been attempts at stock enhancement with limited long term tracking and survival. In 2013, we outplanted 69 adult farm raised green abalone (>14 cm) in Newport Beach, for a one year study to track movements and monitor survival. Several strategies were studied to specifically address problems with previous efforts including the large size of the outplanted animals, tagging mechanisms, monitoring rigor, and outplanting method. Frequent monitoring allowed for detailed tracking and maintenance of the tags. The results have yielded 43% survival, 12 missing, and 27 confirmed mortalities. Temperature appears to play a role in movements. During periods of higher water temperatures, movement increased. The literature suggests the average survival rates of outplanted abalone being about 10%–30%. We believe our higher than average survival rates are primarily due to the size of the abalone outplanted which are easier to track and less prone to predation. We suggest that successful stock enhancement of this species of concern could be accomplished by outplanting large genetically wild adult abalone in small, close communities where they act as "larval factories" for areas where abalone were historically abundant.

### 106 SPECIES-SPECIFIC RESPONSES TO INCREASING ENVIRONMENTAL VARIABILITY ARE DRIVEN BY DIFFERENCES IN PHYSIOLOGICAL PERFORMANCE CAPACITY

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Anthropogenic global warming is a major driver of changes in population dynamics, species interactions, and community structure from local to global scales. Changes in average temperature have already been implicated in geographic range shifts of many species and increasing temperature variability is likely to be an additional source of disturbance, as it increases the risk that species' tolerance limits will be exceeded. Direct effects of thermal variability on individual fitness are mediated through physiological sensitivities. We measured metabolic rates in air and water as a function of temperature for a guild of congeneric grazing limpets at Hopkins Marine Station, Pacific Grove, CA. In general, thermal performance curves were nonlinear and asymmetric, such that metabolic rate rose gradually with temperature to a maximum at some intermediate value and then dropped quickly at higher temperatures. Across a range of temperatures, the high intertidal species exhibited consistently lower respiration rates during aerial exposure and higher upper thermal tolerance limits than the mid intertidal species. Coupled with a novel experimental approach to manipulate temperature variability of limpets during aerial exposure in the field, our data suggest that characteristic differences in physiological performance may be a key determinant of species-specific responses to future environmental conditions.

### 107 COMPARISON OF DIETS AND DIETARY SAMPLING METHODS FOR NESTING CALIFORNIA LEAST TERNS (STERNULA ANTILLARUM BROWNI) AT ALAMEDA POINT IN SAN FRANCISCO BAY, AND PURISIMA POINT ON THE CENTRAL CALIFORNIA COAST

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This study was undertaken to evaluate diet and diet assessment methods at two nesting sites of the California least tern (*Sternula antillarum browni*). Because the least tern is an endangered species, accurately assessing diet is important to determining the reasons for successes and failures of individual colonies. Diets at Alameda Point and Purisima Point were compared using dropped fish and hard parts (i.e. otoliths and scales) from regurgitated pellets and fecal samples. These data were correlated with breeding success and ocean productivity in the form of chl a (mg $m^{-3}$). Diets were different at each site (26% similar) and assessment methods showed similar results at Alameda Point (79% similar), but not at Purisima Point (24% similar). The fish dropped at both sites were significantly larger than those consumed, with Purisima Point terns mostly dropping deep-bodied species typically not consumed and Alameda terns dropping larger sizes classes of the s ame species that were consumed. However, the pellets and feces at Purisima Point were collected from adults and chicks, while at Alameda Point they were collected from mostly chicks. Thus, the differences at Purisima Point may also be because of differences in adult and chick diet, and not solely due to sampling methods. Chl a does not seem to be a good indicator for breeding success, but may show a better relationship with the abundances of prey items. Dropped fish samples are an easy and non-invasive method to assess diet, while identifying hard parts is more intensive and time-consuming. Hard part assessment may be closer to actual diet compared to dropped fish alone.

## 108 WHITE CROAKER HIERARCHIAL HABITAT SELECTION: THE PRIMARY AND SECONDARY DRIVERS OF WHITE CROAKER MOVEMENT IN THE LOS ANGELES AND LONG BEACH HARBORS

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White croaker (*Genyonemus lineatus*) are a commonly caught and consumed species off local fishing piers near the Los Angeles and Long Beach Harbor. They are a sentinel fish species for contamination due to their susceptibility to pollutants and direct interaction with contaminated sediments through their benthic foraging behavior. Determining which habitats white croaker select for may be indicative of where these fish are acquiring contaminants. Fine-scale fish movement data and mixed effects models coupled with environmental and biotic data were used to quantify white croaker movements and habitat selection in the LA-LB Harbor. White croaker exhibited hierarchical habitat selection in which the primary drivers included potential prey density (polychaete density) and dredged (versus nondredged) areas. Secondary drivers included depth, sediment total organic carbon, grain size, and substrate type. White croaker selected for non-dredged areas with high polychaete densities (406–700 individuals 0.1 $m^2$). White croaker also selected areas of high sediment total organic carbon (4.8–8.1%) with sediment grain sizes below 23.5 μm, which constituted substrate types of clay and silt. White croaker exhibited diel shifts in depth and occupied shallower depths at night than during the day. Time of day and region of the harbor were important predictors of depth preference. Knowledge of which habitats are preferred by white croaker will aid in sediment remediation efforts aimed at reducing contaminant tissue concentrations of white croaker in the harbor. Additionally, white croaker habitat preferences can be used to predict the species' spatial response to changing environmental conditions in the harbor.

## 109 THE INFLUENCE OF ENVIRONMENTAL VARIATION ON YEAR-CLASS STRENGTH IN WHITE SEABASS (*ATRACTOSCION NOBILIS*) OF SOUTHERN CALIFORNIA

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During warm climate events, growth rates can increase in fish, suggesting that they benefited from the increase in sea surface temperatures. Previous studies have shown that species of fish can either thrive or dramatically decline in these shifts in climate. In Southern California, climate events such as El Niño Southern Oscillation and Pacific Decadal Oscillation can greatly influence the growth of a species. Otoliths are the calcium carbonate ear stones found in fish. In the formation of an otolith distinct bands are seen within the structure, which represent annual and seasonal variation at a point in time. White seabass (*Atractoscion nobilis*) was a prominent commercial and recreational fishery species in Southern California but had decline substantially by 1982, largely attributed to overfishing. Recent studies have shown signs that the native population is in recovery and may benefit from El Niño events through increased growth rates.

The purpose of my study is to determine if year-class strength in white seabass is influenced by climate induced changes in sea surface temperature, where year-class strength will be stronger in the years following a warm period. Otoliths collected as part of the fisheries independent assessment of white seabass were used to estimate year-class strength for the species from 1996–2001. The results from this study will ultimately determine the impact of environmental variation on year-class strength of white seabass.

## 110 THE RELATIONSHIP BETWEEN PLANT BIODIVERSITY AND ECOSYSTEM FUNCTION IN A COASTAL WETLAND

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The loss of as much as 90% of coastal wetlands in California over the past century has motivated research aimed at understanding the effects of such habitat decline. Although many of the most significant impacts of habitat loss are assumed to be related to reductions in species diversity, investigations into the relationship between biodiversity and ecosystem function (BEF) have historically focused on terrestrial communities. Our research explores the BEF relationship in Colorado Lagoon, a recently restored salt marsh in Long Beach, CA. We hypothesize that: (1) experimentally increasing plant diversity will result in higher primary productivity and increased recruitment of native salt marsh plants; (2) observed species-specific variation in individual demographic parameters will be correlated with variation in plot-level responses; and (3) variation in demographic parameters and resulting ecosystem processes among treatments at a given diversity level will be correlated with species-specific functional traits. Preliminary data suggest that higher diversity treatments exhibit decreased plant mortality and increased diversity of juvenile recruits and that species specific photosynthetic rates vary across the intertidal gradient. We are currently evaluating the degree to which plant life history traits correlate with observed functional differences to help managers assemble the most successful planting palettes for restoration.

## 111 DEEP SEA MINING OF POLYMETALLIC NODULES IN THE CENTRAL EASTERN PACIFIC AND KEEPING THE INTEGRITY OF THE ABYSSAL MARINE ENVIRONMENT

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Now that the deep sea mining of polymetallic nodules on the abyssal plain (4000 to 6000 m depth) of the central Eastern Pacific is to begin in the next few years, serious consideration must be given to the possible effects on the abyssal environment. The question here is will the mining of nodules on the abyssal seafloor threaten the extinction of any benthic fauna species. Abyssal organisms in the Pacific Ocean have very large distribution areas and occur in discontinuous patch ecosystems. The most dominant organisms in the abyssal plain are the megafauna holothurians, in particular, the large mobile epifauna holothurians. In the polymetallic nodule areas of the central Eastern Pacific, two species of cosmopolitan distributed mobile epifauna holothurians dominate the abyssal ecosystem. These two species are *Psychropotes longicauda* and *Oneirophanta mutabilis*. Observations of deep sea holothurians on abyssal plains in the Pacific and Atlantic Oceans show that these two species of mobile epifauna holothurians along with other species are quite active in their migratory behavior moving constantly on the abyssal plain. The deep sea mining of polymetallic nodules on the abyssal plain of the central Eastern Pacific will not result in any significant effects on the abyssal environment because of the very large distribution areas for abyssal plain fauna, the patch distribution of its ecosystems and constant migrations of mobile epifauna. In addition, reserve areas of the Clarion Clipperton Fracture Zone seafloor have been put in place by the International Seabed Authority.

## 112 THE EFFECT OF VITAMIN D ON NEONATAL LUNG DEVELOPMENT

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Vitamin D (1α,25(OH)2D3) is an effector of fetal lung maturation. It stimulates key alveolar epithelial-mesenchymal interactions, resulting the maturation of the developing lung. However, systemic

administration of vitamin D can lead to toxicity and increased chances of hypercalcemia. Using a nebulized approach instead of systemic administration, this study tested for an increase in lung development after administration of vitamin D. One day old Sprauge-Dawley rat pups were either administered a placebo, 25D (100 ng/kg/day), or 1,25D (10 ng/kg/day), once daily for 14 days. After the $14^{th}$ day, the lungs were harvested and tissue samples were collected for analysis. Western blot analyses were conducted for mesenchymal [Peroxisome Proliferator-Activated Receptor-$\gamma$(PPAR$\gamma$)] and epithelial [surfactant protein B(SPB)] markers. The results showed that the lung protein levels of both PPAR$\gamma$ and SPB were significantly higher with nebulized 25D and 1,25D administration vs. the control group. It can be concluded that the administration of nebulized vitamin D can enhance lung maturation without the complications associated with the systemic administration of vitamin D. The results of this study could be useful to prenatal children who are born with underdeveloped lungs and therefore have trouble breathing.

## 113 FEEDING ECOLOGY OF THE NON-NATIVE ITALIAN WALL LIZARD (PODARCIS SICULUS) IN URBAN SOUTHERN CALIFORNIA

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The Italian wall lizard, *Podarcis siculus*, is an opportunistic, omnivorous, lacertid lizard native to Italy and the east Adriatic coast. Multiple introduced populations of this species occur in the Mediterranean region, and *P. siculus* was also introduced to an urban Southern California neighborhood in 1994. In this study, we looked at the feeding ecology of California *P. siculus* to determine what affects it is having on the flora and fauna of its new environment. We conducted field surveys to determine the current distribution of this population and obtained voucher specimens for gut content analysis. These analyses demonstrate dietary overlap with the native Western Fence Lizard, *Sceloporus occidentalis*, and Southern Alligator Lizard, *Elgaria multicarinata*, which also occur in this neighborhood. Few native lizards were observed sympatrically with *P. siculus* suggesting that direct competition could be causing localized declines of these native lizards. Our study also suggests that *P. siculus* may prey upon native lizards. Adult *P. siculus* were found to cannibalize smaller individuals, suggesting that predation of native lizards is likely.

## 114 INCREASING POWER OUTPUT BY REDUCING THE WINDMILL BLADE-TIP VORTEX

**E.O. Frost**. Chaminade College Preparatory, West Hills, CA

As the blade of a horizontal axis windmill passes through the air, air pressure forms a vortex at the tip. The vortex takes energy away, making less available for the conversion into electric power. My study compares the performance of a symmetrical and a flat-bottomed airfoil to those with a winglet added to the blade tip. My hypothesis is that the airfoils with the winglet will produce greater electrical output than the airfoils without winglets. The windmill I used was inspired by a US DOE report in 2009. For each series of experiments, after the rotor reached a steady state of rotation, I recorded 20 observations. I averaged the results and calculated the standard deviation. I calculated the T statistic for each pair of experiments. For the 2 in symmetrical and flat blade experiments, no pair of data sets had a statistically significant difference in the observations with and without the winglet, to produce a confidence level of 95%. The five and ten degree static angle tests for the 5 inch flat blade did have winglet output average results greater than the results for blades without winglets; however the confidence level T statistic was not statistically significant. Therefore the analysis of the experimental data shows that my hypothesis could not be supported to a 95% level of confidence.

## 116 THE INTERPLAY BETWEEN SASH1 AND CEACAM1 IN CANCER CELLS

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SAM and SH3 domain containing protein 1 (SASH1) is identified to be a tumor suppressor gene for breast cancer. Reduced expression of SASH1 has been found in 74% of breast tumors when compared to

normal breast epithelial cells, as well as in lung and thyroid tumors. The carcinoembryonic antigen-related cell adhesion molecule 1 (CEACAM1), another promising tumor suppressor protein, has been shown to upregulate SASH1. To better understand the relationship between SASH1 and CEACAM1, we explored the localization of SASH1 in the presence or absence of CEACAM1 and the binding partners of SASH1. SASH1 appeared in the nucleus and the cytoplasm of the immortalized, ovarian cancer cell line HeLa in the both presence and absence of CEACAM1. Furthermore, beta-actin was identified as a binding partner of SASH1. We have also determined SASH1 does not normally have tyrosine phosphorylation in HeLa cells. Further analysis of the SASH1 tyrosine phosphorylation status in He La cells transfected with CEACAM1, as well as the SASH1 serine and threonine phosphorylation status in HeLa cells, should shed more light on the function of SASH1.

## 118 GLIOBLASTOMA MULTIFORME IN THE LATINO POPULATION

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One of the most common brain cancers is Glioblastoma Multiforme (GBM). A patient with this deadly cancer, which spreads insidiously throughout the brain, has an average survival of fourteen months. There is, however, little published data on the prevalence and survival rates of GBM in the Latino population of the U.S. Because the Latino population is projected to double by 2030 in the U.S., understanding the characteristics of GBM in this population is vital to ensure longer survival. Thus, this study examined survival data of Latino patients with GBM, all of which was obtained from the U.S. Surveillance, Epidemiology, and End Results (SEER) program. Data of patients with GBM diagnosed from 1993–2010 were included in this study cohort, with all patients classified by ethnicity and treatment received. Descriptive statistics were utilized to describe the population; when appropriate, T tests and log-rank tests were used for comparison among Latino sub groups. Analysis of data indicated GBM survival rates were highest among South/Central American populations, followed by the Puerto Rican population with one-year survival rates of 42.1% and 38.9% respectively. Mexicans, conversely, experienced a one-year survival rate of 34.4%. While Hispanics overall had a better one-year survival rate than Non-Hispanics/Latinos and Non-Hispanic Whites, it was not statistically significant ($p=0.62$ and $p=0.60$ respectively). Nevertheless, this slight variation in data can suggest possible genetic differences associated with GBM, therefore affecting patient survival. Such knowledge in addition to information on the molecular characteristics of GBM within the Latino population may help design personalized treatment.

## 119 MICRORNA-29 REGULATES DNA METHYLATION BY TARGETING ONCOGENE TET2

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MicroRNAs are small, noncoding RNAs that post-transcriptionally regulate gene expression by binding directly to complementary sequences located within the 3' UTRs of target mRNAs, thereby inhibiting their translation or resulting in target degradation. The tet methylcytosine dioxygenase (TET) family of enzymes (TETs 1–3) plays a key role in DNA methylation, a critical process in gene expression and cell differentiation. Mutations in TETs are known to lead to aberrant changes in DNA methylation patterns that are strongly associated with a variety of diseases. Indeed, TET2 is frequently mutated in a variety of hematopoietic malignancies. In this study, we identified 4 potential binding sites for microRNA-29 (miR-29) in the 3'UTR of TET2. To confirm the hypothesis that miR-29 directly regulates TET2 expression, the 3'UTR of TET2 containing these sites was cloned downstream of the firefly luciferase gene in the pMIR-REPORT vector. The reporter plasmid was co-transfected with either a miR-29 mimic or a miR-mimic control, and luciferase levels were measured after 48 hours. The luciferase analysis revealed that the reporter's activity was significantly suppressed by the miR-29 mimic, resulting in over a three-fold decrease compared to the control. qRT-PCR analysis further confirmed this hypothesis on the endogenous level, showing that TET2 mRNA levels decreased by 25% when the miR-29 mimic was transfected and compared to the control. Thus, our data indicate that miR-29 directly targets TET2, and therefore it may impact the development of hematopoietic malignancies as a novel layer of regulation for

DNA methylation. Further studies will characterize miR-29's oncogenic role with global methylation patterns.

## 121 A NOVEL REPORTER SYSTEM FOR ANALYZING AND EVALUATING A SMART BOMB APPROACH TO ANNIHILATE HIV

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The intent of this research is to use a reporter system to assess the effectiveness of a newly discovered smart bomb approach to combat HIV. If a special plasmid composed of the glycoprotein-160 HIV gene, and the two reporter genes Green Fluorescence Protein and Firefly Luciferase, is able to be successfully inserted into human T-cells to create cells that look like HIV, then tests can be performed and data can be collected to analyze the effectiveness of the therapeutic aptamer-small interfering RNA(siRNA) chimera, a new smart-bomb approach, to destroy the HIV cell. A plasmid that carries the 3 genes through molecular cloning was created and was inserted into a human T-cell so that the cell would express the HIV-glycoprotein on the cell surface, thereby mimicking an HIV-infected cell. Upon successful construction, the plasmid was transformed into bacteria to produce more plasmids. Then, taking the purified DNA plasmids, they were transfected into human cells through lentiviral packaging to create lentivirus. Human CD4+ T-cells were infected after the lentivirus multiplied. These infected cells were then tested by using flow cytometry and luciferase assays in order to analyze if the transgene in the cell was producing the HIV outer receptor protein, GFP, and Ffluc. The results indicated that at least 55% of the infected cells were producing GFP while the luminometer readings for the luciferase assays confirmed the presence of luciferase. Thus, the reporter system is proved to be effective to track the progress of aptamer-siRNA "smart bomb" in the fight against HIV.

## 122 DIVERSITY OF MARINE MICROBES COLONIZING POLYETHYLENE FOOD PACKAGING MATERIALS

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Polyethylene plastic is one of the most widely used plastics in the world, specifically in the food packaging industry. Poor disposal practices results in much of this polyethylene finding its way to the ocean. Aside from the immediate threat of ingestion by marine animals, little research has been done regarding how polyethylene plastic affects ocean microbial ecology. Several samplers were deployed at Heal the Bay's Santa Monica aquaria facility and off the actual pier itself, each filled with shredded polyethylene food packaging material. Nucleic acids isolated from the biofilm material harvested from the sampling devices will be amplified for the 16S rDNA gene. Analyses of the sequences from the array of materials tested may reveal information on the communities colonizing different types of polyethylene plastics. Understanding how plastics like polyethylene affect marine life is essential to knowing how humans as a species are impacting the environment. These plastics could potentially be farming populations of harmful or otherwise detrimental bacteria, so researching exactly what happens when trash ends up in the ocean is necessary.

## 123 EMERGING NEW DIABETES TREATMENT STRATEGIES: BETATROPHIN VERSUS ISLET CELL TRANSPLANTATION

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A disease that claims more lives a year than cancer and acquired-immune deficiency syndrome (AIDS) and one increasingly affecting youth is diabetes. Even in light of these high fatality rates for diabetes, there have been no clinical advancements in treatment of this disease in almost a century. In 2013, the discovery of the hormone betatrophin marked a new milestone in diabetes treatment. Unusually low concentrations of betatrophin appear to induce significant proliferation of insulin producing beta cells. Islet cell

transplantation has also become increasingly popular among recent clinical trials. This approach takes donor islet cells and transplants them through a catheter into the kidneys. Transplanted islet cells almost immediately begin to produce insulin. After comparing the data, benefits and risks of both treatments, and formulating a timeline for forthcoming diabetes treatment strategies, we concluded that islet cell transplantation yields greater potential. Most recently, the Mayo Clinic has reaffirmed the potential of this treatment avenue by actively testing stem cell to islet cell differentiation and transplantation. Their software modeling tools will be utilized to simulate the performance of stem cell transplantation this summer.

## 124 COGNITIVE PERFORMANCE IN SCHIZOPHRENIA AND BIPOLAR DISORDER AND THEIR FIRST-DEGREE RELATIVES

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Due to the several notable similarities in symptoms between bipolar disorder (BD) and schizophrenia (SZ), it can be difficult to effectively distinguish and diagnose between these two illnesses. Neurocognitive performance may be able to serve as a potential trait marker for SZ and BD and can suggest the degree of genetic liability with their first-degree relatives. The objective of the current study was to i) examine differences in cognitive performance among control, SZ and BD patient groups, and their first-degree relatives, ii) find possible predictive values for distinguishing between diagnoses, and to iii) determine the severity of the genetic liability of BD and SZ with their first-degree relatives using neurocognitive performance scores. Using post-hoc statistical comparisons in cognitive tasks, significant differences were observed among the groups, suggesting the ability of cognitive performance to serve as a trait marker with predictive value. With further specificity, significant differences between cognitive domains in subtypes of SZ and BD were also found. As expected, controls displayed the least cognitive deficits compared to SZ, BD, and their first-degree relatives. SZ patients with schizoaffective disorder (SAD) showed the highest level of cognitive impairment in all neurocognitive domains. SZ showed higher cognitive impairment than BD in the domains of attention, visual memory, executive functioning, short memory, and perceptual motor skills. However, patients with SZ displayed better cognitive function than BD in immediate memory, delayed memory, and language.

## 125 A MICROFLUIDIC DEVICE FOR BLOOD SEPARATION AND CELL MORPHOLOGY ANALYSIS USING ACOUSTIC MICROSTREAMING AND HYDRODYNAMIC PRINCIPLES

**V. Liu**, M. Simon, M. Patel and A. Lee. Flintridge Preparatory School University of California at Irvine. Mentor: Robin Liu

Blood analysis is a primary test for disease diagnostics, because blood is the most important biological fluid. Current blood analysis equipment is either expensive or labor intensive. As the need for an accurate and efficient blood analysis technology grows, there is a greater demand for micro-devices that can perform such tasks. In this project, a fully integrated microfluidic device was developed to automatically separate human blood cells and perform cell morphology studies on a chip. The device was designed based on acoustic microstreaming and hydrodynamic separation principles to separate Red Blood cells from White Blood Cells. The device was fabricated using soft lithography technology and consists of PDMS microchannels with widths of 10~30 μm. It also consists of pockets that are used to store air bubbles to generate acoustic microstreaming forces, which serves as a micropump to move fluid in the microchannel. This device was tested using human blood samples. During experimentation, we discovered that acoustic microstreaming not only serves as a micropump to move fluids, but can also be used to achieve highly efficient blood cell separation (99.8% rate) similar to that of conventional centrifugation techniques. By utilizing different physical properties of blood cells in addition to the effects of acoustic microstreaming and hydrodynamic channels, we were able to successfully separate RBCs from WBCs based on their size difference, mass, and inertia in addition to performing blood cell morphology analysis to identify various blood cells including RBCs (e.g., sickle cells), and WBCs (lymphocytes, neutrophils, eosinophil).

## 126 A NEW AND PRACTICAL APPROACH FOR MINI-AIRSHIP DESIGN

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This project aimed at developing an approach for the design and fabrication of mini-airships that are minimal in size and capable of carrying usable payloads. A new and practical hull architecture was proposed and investigated. The proposed mini-airship architecture uses flexible films expanded by a skeleton frame to form a super lightweight streamline hull and unpressurized gas cells to provide buoyant lift and partial support to the hull. This approach allows the construction of mini-airships with shapes that are difficult to implement with nonrigid or semirigid hulls. It also allows size minimization that is not achievable by rigid hulls. Rigorous design procedures were followed to calculate the drag, weight, and structural parameters, and a mini-airship was constructed for demonstration. The mini-airship was 2.5 m long with a maximum diameter of 1.0 m and a volume of only 1.12 cubic meters. The hull streamline was scaled from Model-111 in NACA Technical Report TN-614 for low drag at low speed. Two unpressurized gas cells were used to prevent buoyancy center shifting when they are partially inflated. Two propellers with 12″ diameter and 6″ pitch were installed in the front to generate differential thrust. A micro servo was used to adjust pitch moment. An onboard wireless radio received operation signals from a remote controller. The entire airship excluding the battery (0.29 kg) weighed only 0.45 kg. The payload capacity was 0.3 kg with additional 0.16 kg margin. In conclusion, this project demonstrated a viable approach for designing mini-airships with advanced streamline shapes, minimal sizes, and practical payload capacity.

## 128 INVESTIGATING HEART FUNCTIONS WITH CARDIAC MRI

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Left ventricular ejection fraction (LVEF), end-diastolic volume (EDV), and end-systolic volume (ESV), are measurements of how well the heart is functioning. The EDV, ESV, and EF reported for healthy human subjects are 65–240 mL, 16–143 mL, and 55–70%, respectively. LVEF is a powerful predictor of heart failure patients across a wide range of patients with cardiovascular diseases. LVEF below 45% indicates heart failure. Several of the standard noninvasive methods such as the CT (Computed Tomography), MRI (Magnetic Resonance Imaging) and echocardiography (ultrasounds) are used to measure the parameters. The MRI provides high quality images with good soft tissue contrasts. In this study, I investigated the difference of EF between patients and healthy subjects using MRI images, to show that heart function can be evaluated by using MRI. Thirty patients underwent MRI at six months following myocardial infarction. Cine images were used to view the three-dimensional beating of the heart, particularly the left ventricle. In the systolic and diastolic phases of heartbeat, two contour lines were drawn to delineate the endocardium and epicardium. The images were analyzed using software called cvi42 (Circle Cardiovascular Imaging, Calgary, Canada). Then, the EDV, ESV, and EF were calculated. The mean for each measurement was $201.77 \pm 9.27$, $120.47 \pm 51.01$, and $33.53 \pm 14.14$. The results from this experiment are lower than the EF in healthy subjects reported by the literature. EF is an effective and powerful method to measure heart function. The difference of EF between patients with myocardial infarction and healthy subjects can be observed through MRI images.

## 129 A VEGETATIVE SURVEY IN THE MARSH FLATS OF THE BALLONA WETLANDS TO DETERMINE THE OCCURANCE OF NON-NATIVE PLANTS

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Invasive species have become a pernicious ecological threat in degraded wetland ecosystems. They can competitively exclude native plants for resources, causing widespread biotic homogenization, altered nutrient cycles, and decreased biodiversity. The objective of this investigation was to assess the percent of native and invasive plant species diversity across lower and upper salt-marsh habitats at the Ballona

Wetlands, and to characterize some chemical and physical parameters that could control differences in plant diversity. The percent cover of plant species were determined along four 25 m transects; two transects were positioned in the low marsh areas adjacent to tidal channels and inundated by water during periods of high tide, and two in the upper marsh areas seldom wetted by tidal flows. Along each transect, plants were surveyed in five randomly placed 1 $m^2$ quadrates. Three soil samples were collected from each transect and tested for salinity (ppt), percent organic matter, and grain size (% clay, % silt, % sand). Preliminary results indicated that no non-native plants occurred in the surveyed areas. Soils comprised mostly fine sediments with percent silts and clays usually ranging from 46.8% to 90.87%. Organic matter content varied, ranging from 2.3% to 30.46% while soil salinity was quite variable, ranging from 15 to 88 ppt. Future work will census the plant assemblage in wetland areas of slightly higher elevation where non-native species become abundant, and link soil characteristics to plant diversity through multivariate analytic techniques.

## 130 MECHANICAL PROPERTIES OF CORK SANDWICH COMPOSITES

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Cork is naturally made from a cork tree and exhibits mechanical and acoustic properties that may be of interest for certain aerospace applications. For instance, researchers have found cork conglomerate to have superior acoustic dampening performance as compared to foam when used as the core material in a composite sandwich structure. However, there is currently very limited information about the mechanical properties of cork conglomerate sandwich composites. This study conducted comparative tests of the mechanical properties of cork conglomerate sandwich composites versus sandwich composites utilizing the more conventional synthetic foam core materials.

## 131 SHIFTS IN METHANOTROPH COMMUNITY STRUCTURE AT DEEP SEA METHANE SEEPS IN RESPONSE TO OXYGEN AND METHANE CONCENTRATIONS

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Bacterial aerobic methanotrophs convert methane into cellular carbon and energy, thereby contributing to the basis of food web in methane-rich environments. The methanotrophic communities at deep-sea methane seeps (e.g. Split Ridge, Southern California), form the trophic base of a diverse faunal community but have not yet been characterized. In particular, the extent to which methane and oxygen drive this population has not been well characterized. As global climate continues to precipitate shifts in marine environmental conditions, including the expansion of oxygen minimum zones and the generation of significant methane pools, methanotrophic communities may be expected to shift. In this study, we examined how methane and oxygen concentrations affect the composition of naturally-occurring methanotrophic populations. Using sediment recovered from Split Ridge, we subjected sediment communities to a gradient of oxygen, methane, and temperature by incubating t he live sediment for two weeks with headspaces of 0%, 10%, and 20% atmospheric air arrayed with 0% and 20% methane gas at 4oC, 10oC, and 23o. Oxygen- and methane-rich conditions yielded the most methanotrophic DNA; also, further examination showed that the methanotrophic population shifted towards aerobic phylotypes; one such phylotype has been recovered in culture for future controlled analysis. Bottles that did not contain oxygen yielded slow, anaerobic or microaerobic growth. Methanotrophic communities might exhibit similar reactions within spreading oceanic anoxic zones. If that proves true, we risk losing an important link in the carbon cycle and a key component in reducing atmospheric levels of greenhouse gas.

## 133 CONVERTING PATIENT FIBROBLASTS TO MOEL ASTROCYTE TOXICITY IN FAMILIAL AND SPORADIC ALS

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Amyotrophic Lateral Sclerosis, or Lou Gehrig's disease, is one of the neurodegenerative motor neuron diseases. ALS is divided into two groups: those who have a familial history of ALS and those who have a sporadic, or random, case of ALS. Animal models cannot be made for the sporadic cases of ALS. This study focuses on the modeling of both familial and sporadic cases of ALS in the laboratory without the use of animal models. Within the experiment, the conversion method was used to convert fibroblast cells back into induced neuronal progenitor cells (iNPC) after converting it back to its stem cell stage. At each step, images of the cells or immunostainings were taken to verify the differentiation of the fibroblast cells to iNPCs, then induced astrocytes. From the astrocytes, their toxicity (one of the causes of neurodegeneration in ALS) is verified by plating iNPCs onto the astrocyte co-culture. The verification of the induced astrocytes cocultures as toxic, supports the hypothesis that it is possible to directly create a model system for familial and sporadic ALS from patient skin cells.

## 134 AN EXPERIMENTAL STUDY OF THE EFFICACY OF GAME AUGMENTATION LEARNING EFFECTS ON COMPUTER AIDED INSTRUCTION (CAI) OF PHYSICS SCIENCE TASKS

**M.B. Eliot**. 16033 Bolsa Chica St., 104 Huntington Beach, Ca 92649. Mentor: L. Eliot

Web-based online gaming and simulations have a great potential to serve as an enhancing adjunct to traditional Computer Aided Instruction (CAI) for improving student academic achievement on physics science learning tasks. An experiment was designed and performed to study the efficacy of game augmentation learning effects in a CAI physics science instructional context. Experimental subjects consisting of high school physics students were divided into a control group and an experimental group. Both groups used traditional CAI to learn a new physics task involving electrical circuit design. The experimental group additionally used an aligned web-based online game (the treatment) to further learn the same physics task. The subjects were administered a pre-test and a post-test to assess their physics task learning outcomes. Using a two-tailed T-test at the 0.05 significance level, the results indicated that there was a statistically significant difference between the outcome of the control group and the experimental group, and the experimental group had greater learning outcomes than the control group. This result provides support for the efficacy of using web-based online games as an adjunct to CAI for the learning of physics science tasks.

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Cover: *Chorizanthe robusta* var. *hartwegii* (Scotts Valley spineflower, Polygonaceae), federally endangered. Glenwood Open Space Preserve in Scotts Valley, Santa Cruz County, California.